USAID/OAS
Caribbean Disaster Mitigation Project

Planning to Mitigate the Impacts of Natural Hazards in the Caribbean

December 1997

Unit of Sustainable Development and Environment
General Secretariat, Organization of American States

Acknowledgements

This workshop and manual were developed under a collaborative project between the Caribbean Disaster Mitigation Project (CDMP) and the Disaster Emergency Response Management Systems (DERMS) project. The CDMP is a five-year project, executed by the Organization of American States, Unit of Sustainable Development and Environment (OAS/USDE) for the US Agency for International Development, Caribbean Regional Program (USAID/CRP). Funding for the CDMP is provided by USAID's Office of Foreign Disaster Assistance. DERMS is a two year United Nations Development Programme-funded project, executed by CARICOM and implemented by the Caribbean Disaster Emergency Response Agency (CDERA).

This manual was principally authored by David Brower, with assistance from Anna Schwab. The author would like to thank Jennifer Worrell Campbell of USAID/CRP for initiating the mitigation planning project, and Jan Vermeiren, Steven Stichter (OAS/CDMP) and Jeremy Collymore and Judy Thomas of CDERA/DERMS for supervision of this project. The technical working group for this project provided valuable insight and direction for the manual and workshop. Members of the working group included Jennifer Worrell Campbell, Judy Thomas, Jeremy Collymore, Steven Stichter, Aeden Earle and Paul Saunders (Jamaica Office of Disaster Preparedness and Emergency Management).

Hazard Mitigation Planning Manual

Section I.
Hazard Mitigation Planning—An Introduction

Natural Hazards and Disasters

Natural hazards are part of the world around us, and their occurrence is inevitable. Floods, hurricanes, volcanoes, earthquakes, wildfires and other hazardous events are natural phenomena that we cannot control. These events can result in great changes to the natural environment: fire can destroy forests, coastal storms can create and fill inlets and move barrier islands, high winds and wave surge can wreak havoc in wetlands, tornadoes can uproot trees, earthquakes can alter the landscape. However, despite their power these occurrences are part of the natural system. The natural environment is amazingly recuperative from the forces of wind, rain, fire and earth and can regenerate with remarkable resiliency, even restoring habitat and ecosystems in time for the next generation of plant and animal life to begin anew.

It is when the man-made environment intersects with these natural phenomena that “disasters” result. Disasters occur when human activity, such as buildings, infrastructure (roads, pipelines), crops, livestock and other land uses take place in the path of the forces of nature. The human environment, particularly the built environment, is not nearly as indestructible nor as resilient as the natural one, and the occurrence of a natural hazard can result in the debilitation of an entire community for many years following the event.

Unfortunately, the frequency of disasters is rising at an alarming rate, not necessarily because natural hazards have become more frequent (although such phenomena do occur in cycles of more and less frequency), but because more and more people have chosen to live and work in locations that put them at risk. Often human development has taken place in areas of risk from coastal storms, repeated flooding and seismic activity, often with little or no attention to the need for sound building practices or land use policy. As a result, risk of disasters occurring in the wake of natural hazards has grown exponentially.

While we cannot prevent natural hazards, we do have some means at hand to reduce some of their adverse consequences. We have tools and techniques which, when put into effect in a timely fashion, allow us to avoid the worst-case scenario when a hazard does occur. By managing the characteristics of the existing and future human environment in a community before a hazardous event occurs, we can mitigate many of its negative impacts so that a *disaster* is less likely to result or will at least be of diminished magnitude.

This manual is intended to serve as a guide to policy makers, business leaders, planners, disaster managers, builders and developers, environmental and conservation groups, private citizens and others who wish to make use of available mitigation tools and techniques to decrease the vulnerability of their community to future hazards. By following the steps outlined in the manual, a government can create an effective plan for mitigating the impacts of the natural hazards that occur in the jurisdiction.

The Four Elements of Comprehensive Emergency Management

Comprehensive emergency management is a widely used approach at all levels of government to deal with the inevitability of natural hazards and their potential to cause disasters in a given community. The components of a comprehensive emergency management system include:

- *Preparedness* activities involve at least two types of activities. Structural activities include actions to prepare for the imminent arrival of a hazard event, such as putting up storm shutters and sandbagging. Non-structural activities involve taking steps to minimize damage to personal property and to minimize harm to individuals. For instance, anchoring boats and storing outdoor furniture in sheds prior to the arrival of a hurricane will lessen the chance of damage to personal property. Following recommendations to evacuate an area will lessen the chance of harm to individuals. Preparedness activities include development of response procedures, design and installation of warning systems, exercises to test emergency operational procedures and training of emergency personnel.

- *Response* activities occur during or immediately following the disaster and include time-sensitive activities such as search and rescue operations, evacuation, emergency medical care, food and shelter programs. Response activities are designed to meet the urgent needs of disaster victims.

- *Recovery* activities are emergency management actions that begin after the disaster, as urgent needs are met. These actions are designed to put the community back together and include repairs to roads, bridges and other public facilities, restoration of power, water and other municipal services and other activities that help restore normal operations to a community.

- *Mitigation* activities reduce or eliminate the damages from hazardous events. These activities can occur before, during and after a disaster and overlap all phases of emergency management. Structural mitigation pertains to actions such as dam and levee projects to protect against flooding, constructing disaster-resistant structures, and retrofitting existing structures to withstand events. Non-structural mitigation activities include development of land use plans, zoning ordinances, subdivision regulations and tax incentives and disincentives to discourage development in certain high-hazard areas. Mitigation also includes education programs for members of the public about the hazards to which their community is vulnerable, as well as the importance of mitigation and how to prepare their property to withstand a disaster.

The Concept of Mitigation and Its Importance

The tension between natural hazards and the decisions people make regarding land use and the built environment is mounting every day. We must take steps to significantly reduce the vulnerability of people and their communities to natural hazards; this can only be done through mitigation. Mitigating the impact of natural hazards involves recognizing and adapting to natural forces and is defined as *any sustained action taken to reduce long-term vulnerability of human life and property to natural hazards.* This definition highlights the long-term impact that effective mitigation can produce. While the actions involved in the preparatory, response and recovery phases of emergency management are related to specific events, mitigation activities have the potential to produce repetitive benefits over time and should concern events that may occur in the future.

Hazard mitigation can be viewed as the foundation of emergency management and should be interwoven with all the other phases of comprehensive emergency management program. The aftermath of a disaster provides a unique window of opportunity to assess the damage that has befallen a community and to elucidate its causes. This allows members of the community to take action during re-building to prevent or diminish the same disaster when the next natural phenomenon occurs. Whether applied in post-disaster reconstruction or during pre-disaster planning efforts, hazard mitigation provides planners with guidelines for reducing vulnerability to future disaster-related damages. By developing mitigation programs that affect the impact of future disasters, planners can break the cycle of damage, reconstruction and repeated damage.

A fundamental premise of mitigation strategy is that current dollars invested in mitigation will significantly reduce the demand for future dollars by reducing the amount needed for emergency recovery, repair and reconstruction following a disaster. Mitigation can also provide a degree of socioeconomic continuity in the community by reducing the social and economic disruption that often accompanies a hazardous event through damage to transportation and communication systems, dislocation of people, loss or interruption of jobs and closing or disabling of businesses, schools and social outlets. Mitigation also calls for conservation of natural and ecologically sensitive areas (such as wetlands, floodplains and dunes) which enables the environment to absorb some of the impact of hazard events. In this manner, mitigation programs can help communities attain a level of *sustainability*, ensuring long-term economic vitality, social and environmental health for the community as a whole.

Section II.
Rationale for Mitigation Planning: To Influence Decision-Makers

Mitigation is the only component of comprehensive emergency management that has the potential to break the cycle of damage and reconstruction that can occur when a community is subjected to repeated natural hazards. To be effective, a mitigation strategy must be in place and ready for immediate implementation when the appropriate window of opportunity opens. This can only be done through advance preparation; i.e., planning.

First and foremost, a hazard mitigation plan can be an effective vehicle for establishing commitment to mitigation goals, objectives, policies and programs. By articulating what the government hopes to achieve, the plan can serve to establish an important connection between the public interest and mitigation measures to be employed. While the plan is useful for articulating the vision and developing the programs and initiatives that encourage and support community-based implementation, the real success or failure of the hazard mitigation plan depends on decisions made by individuals—in both private and public sectors. To this end, the hazard mitigation plan provides a medium to inform the community about natural hazards and about mitigation, increasing public awareness of the risks present in the community, as well as the resources available to reduce those risks. Achieving widespread public awareness of natural hazards in a community will enable citizens to make informed decisions on where to live, purchase property or locate a business and how to protect themselves and their property from the impact of natural hazards. In the public sector, decision-makers who are well-informed and well-guided by a mitigation plan can carry out their daily operational activities in a manner that will include mitigation concepts. The plan, then, guides the implementation of goals, objectives, policies and programs for both public and private sectors as it educates the community.

A meaningful mitigation plan also provides the impetus for the government to become a "good leader" in the forefront of mitigation strategy. Governments at all levels, must, through their own activities in the built environment, set a good example in terms of mitigation. All new public facilities should be sited away from hazardous areas and should be built to meet or exceed model building codes and standards or their substantial equivalent. Existing public structures should be retrofitted to withstand the impact of natural hazards, protecting public investment. By demonstrating first-hand the efficacy of mitigation, as well as the level of commitment the government is willing to put forth, governments will provide incentive to private owners and builders to carry out the goals and policies of the hazard mitigation plan as well.

Section III.
The Hazard Mitigation Plan

There is ample evidence that the impacts of natural hazards on the human environment can be lessened and perhaps even avoided altogether by appropriate action taken well before the hazardous event occurs. The most effective way to ensure that this action takes place is through the preparation and implementation of a comprehensive hazard mitigation plan. A plan is a written statement of the existing and potential future situation, a review of the alternatives and recommendations on how to meet goals and objectives. Plans are developed as guides and, when implemented, affect the future by not leaving it to chance.

This section describes in brief the essential components of a typical hazard mitigation plan. The first two sections highlight the elements that can be included in a plan and describe some of the more pertinent characteristics of an effective mitigation plan. The final portion of this section describes the various types of hazard mitigation plans that are possible. It is important to note that this section describes these concepts in a generalized manner; this manual is not to be used as a rigid one-size-fits-all model. Instead, this manual is designed to be used at any level of government, and the plan that is created should be tailored to meet the particular needs of the jurisdiction for which it has been prepared. Furthermore, since natural hazards affect individual places in different ways, plans for each place should be carefully tailored according to the unique set of circumstances present in that area. Because of the importance of site-specific hazard mitigation planning, national-level plans should include policy encouraging the formation of locally based plans wherever practicable.

Elements of the Hazard Mitigation Plan

While a hazard mitigation plan should be tailored to reflect the jurisdiction's unique mitigation needs, there are certain common elements that should be included in most mitigation plans. This section of the manual describes these elements briefly, according to the following outline. (For a more detailed discussion of how to prepare these elements and the plan appendices, see Section IV.)

Elements of the Hazard Mitigation Plan

1. Rationale/Statement of the Problem
2. Basic Studies
   a. Hazard Identification and Definition
   b. Probability Analysis
   c. Vulnerability Analysis
   d. Capability Analysis
   e. Conclusions/Acceptability
3. Goals
4. Objectives
5. Alternative Means of Achieving Goals and Objectives
6. Plans, Policies and Programs
7. Adoption and Implementation
8. Monitoring, Evaluation and Updates/Revisions

Rationale/Statement of the Problem

The plan should begin with an introductory section explaining the rationale behind the hazard mitigation plan. This element should include a generalized statement of the problem to be solved by the plan and what the government hopes to achieve in broad terms. More concrete and detailed expressions of the government's aspirations in terms of hazard mitigation and how they will be fulfilled will be articulated in other elements of the plan, such as the Goals and Policies sections, but the main points should be introduced at the outset.

The rationale section of the plan should also highlight the ways in which the plan will be used: to influence decision-making in both the public and private sectors, to educate residents and investors and to minimize the impacts of future natural hazards.

Basic Studies

The hazard mitigation planning process begins with the recognition that systematic steps must be taken to reduce the continued exposure to losses from natural hazards. The first of these steps logically involves an accurate *identification and definition* of the natural hazards that affect an area and the impacts, e.g. high wings, heavy rains, earth shaking, etc. they might have upon the people and the built environment. Such an analysis is crucial to an effective hazard mitigation plan, for while we know in general terms which broad geographic areas are subject to which natural hazards, we need a clear understanding of the type and extent of the potential impacts of hazards on communities to make decisions about which mitigation actions should be undertaken. At a minimum, the major natural hazards should be described in terms of probability, frequency, magnitude and distribution. The identification must be as site-specific as possible—what areas are likely to be affected by what hazards and in what way? The hazards should be analyzed and data presented in such a way so that it provides useful information in terms of mitigating that particular hazard's impact in that particular locality.

The next step in the background analysis involves an assessment of the potential level of vulnerability within the jurisdiction posed by the hazards. A *vulnerability* analysis indicates what is likely to be damaged by the identified hazards and how severely. The vulnerability analysis is an assessment of the number of lives and the value of the property in those areas that may be affected.

The *capability* analysis is an important component of the hazard mitigation planning process because it identifies and evaluates existing systems of policies and practices that either reduce or increase a jurisdiction's vulnerability to natural hazards. The capability analysis also provides critical information on which types of actions are feasible—in terms of financial resources, political willpower, institutional framework, technical ability and legal authority. Furthermore, the capability assessment can provide a mechanism to cite and take credit for those systems that already exist and are successful in the jurisdiction. This is important to foster community support for continuing or increasing mitigation efforts. Documentation of successful mitigation systems may be necessary for receipt of some forms of disaster assistance.

The foregoing background studies will enable planners and policy-makers to articulate a level of acceptance with regards to the natural hazards facing the jurisdiction. Plan makers can then come to sound conclusions as to which hazards should be addressed and can determine the degree of intensity that should be applied given the vulnerability of the area and the capability of the government to respond.

The hazard identification, probability analysis, vulnerability analysis, capability assessment and conclusions all provide critical background information to plan makers. These data can be presented in an appendix to the hazard mitigation plan rather than as part of the plan itself. This approach emphasizes the appropriate role of the assessments as baseline surveys for developing program initiatives, identifying resources and providing an informed basis for developing the plan's goals, priorities and objectives. These background studies establish both a common point of departure and the bounds within which plans and alternatives can be formulated, debated and decided upon; they are not the plan themselves. (For a more detailed discussion of how to prepare these studies see Section IV of this manual. Additional information regarding background analyses also appears in the Appendix.)

Goals

Hazard mitigation goals should be broad in scope and far-reaching in application. This part of the plan should present the vision of the government for mitigation in the area. The goals should identify priorities, yet also acknowledge constraints.

Goal statements should reflect the government's commitment to a comprehensive planning approach; hazard mitigation goals should be fully integrated with other governmental activities. At the same time, goals should also include substantive statements regarding the acceptable levels of risk for the jurisdiction. This can be achieved by drawing on the plan's basic studies, which analyze probability, vulnerability, capability and acceptance data.

Objectives

Objectives are developed as a means of realizing a community's hazard mitigation goals. Objectives are more specific and tangible than goals: Rather than being long-term and general, objectives should be achievable in a finite period of time and the results should be measurable. Since objectives need to be attainable, they should be based on background studies contained in the plan appendices, with direct reference to the capability assessment.

Plans, Policies and Programs

The proposed hazard mitigation plans, policies and programs, will be drawn from the goals and objectives. In other words, the strategies developed as part of the plan are mitigation measures designed to implement the objectives of the plan. This is the "action" section of the plan.

Once feasible alternatives have been selected, each plan, policy and program should be prioritized according to its potential contribution to mitigation efforts, public and private. Highest priority should be given to those measures that will support the hazard mitigation plan's basic philosophy.

The plans, policies and programs that are made part of the plan itself should include both on-going as well as post-disaster mitigation measures. These include programs that are constantly and consistently being implemented, such as those mitigation measures that are insinuated into the government's day-to-day operations. This section should also identify projects to be done on an "as-need" basis and projects, strategies, or programs that may be needed to implement the plan after a disaster.

Adoption and Implementation

The government should adopt the plan officially through the standard legal process for adoption of regulations and policy, including any required public notice and hearings. To be most effective, the plan must be an official plan, not an internal staff proposal.

Once the plan is adopted, the real challenge of hazard mitigation planning involves converting the plan into action. The intent of the implementation section is to intervene in the traditional reactive processes of response and recovery. It is the proactive nature of mitigation planning that leads to successful reduction of hazard vulnerability. Implementation strategies include holding post-disaster meetings, use of special task forces, integration of hazard mitigation activities in the work plans of other agencies or departments and involving the media to garner support and serve as an impetus for implementation in both public and private sectors.

Monitoring, Evaluation and Updates

Monitoring, evaluation and updates are critical elements of an effective hazard mitigation plan and emphasize the dynamic nature of the plan. The completed document is not an end result; rather, completion of the plan is the beginning of the process of reducing future losses from natural hazards.

Monitoring. Monitoring is an important component of the implementation process. Care should be taken to monitor mitigation activities and their effects. It is important to be able to discern if the actions being taken are resulting in the desired objective of lessening the exposure to the hazard. Additionally, overall exposure to hazards needs to be continually monitored to ensure that while this exposure is being decreased in one location, it is not increasing in another. Periodic meetings of the planning committee or other group involved in the plan formulation process may be necessary to review progress to date and recommend changes to the mitigation program based on the results of their monitoring.

Evaluation. No plan is perfect. As implementation proceeds, flaws will be discerned and changes will be needed. The effectiveness of the programs and actions should be evaluated to determine whether the goals and objectives articulated in the plan are still applicable. The original problem statement made in the introduction to the hazard mitigation plan should be assessed for current accuracy. Perhaps the situation has changed. The adequacy of available resources to carry out the plan should be examined. Is there any redundancy that can be eliminated, thereby freeing up funds from one area? Are funds for certain programs or projects inadequate; if so, should more funding be sought? The evaluation section should also trouble-shoot any problems being experienced with implementation, including technical, political, legal and coordination. Finally, the plan should be checked against its time frame—has it been implemented on schedule? Are all windows of opportunity being fully taken advantage of?

Updates/Revisions. The updating and revising step recognizes that hazard mitigation planning is a continuing process and provides an opportunity to measure and evaluate previous mitigation efforts. An updated or revised plan might include a re-evaluation of the hazards and the jurisdiction's exposure to them, a further examination and refining of policies and issues, a re-assessment of existing mitigation capabilities and new or additional mitigation recommendations.

Characteristics of the Hazard Mitigation Plan

Comprehensive

The hazard mitigation plan should be as comprehensive as possible to cover all potential mitigation opportunities. A comprehensive mitigation plan includes all prevalent hazards, strives to achieve multiple objectives, covers a long time horizon and is consistent across recommendations.

Multi-Hazard
An "all-hazards" basis for a mitigation plan makes the most efficient use of limited resources. The plan should, therefore, deal with all possible natural hazards throughout the entire local jurisdiction. At a minimum, the major natural hazards in the disaster area should be examined in terms of probability, frequency, magnitude and distribution. Some other known hazards, or "secondary" hazards should also be included in the analysis. For example, mudslides often accompany severe flooding and should be recognized for their potential impact in addition to that of the catalytic hazards.

In addition to primary and secondary natural hazards, the government should also assess technological hazards and the potential impacts on human beings and their environment. Mitigation strategy cannot deal exclusively with natural hazards and ignore technological hazards if it is to be truly comprehensive. Furthermore, natural hazard events often trigger technological hazards such as ruptured pipelines and building fires, clearly linking natural and technological hazards.

Comprehensive planning also dictates that as many of the impacts of hazards as possible be identified. A section in the plan regarding the socio-economic implications of a disaster could prove invaluable in assessing the entire disaster scenario. Elements of such an analysis should include potential impacts due to the loss of jobs, recovery rate of destroyed and damaged businesses, property tax revenue shortfalls, disrupted real estate markets, migration and disruption of family lives. While many of these variables are subject to fluctuations due to factors other than disaster occurrences, the economic indicators are still useful for the selection and initiation of appropriate mitigation action.

Multi-Objective
The goals and objectives articulated in the hazard mitigation plan need to be comprehensive in scope and cover a wide range of potential mitigative action in both public and private sectors.

However, goals and objectives should not compete. Hazard mitigation has a much greater likelihood for success when goals are effectively combined. Common hazard mitigation goals which can be simultaneously achieved include securing public safety, reducing hazard losses, reducing unnecessary expenditures, eliminating redundancy, lessening exposure to liability and speeding economic recovery.

Furthermore, many mitigation objectives can be accomplished by dovetailing other types of goals or joining forces with other programs and authorities. All communities are encouraged to include the goal of protecting the natural and beneficial values of floodplains and wetlands within their mitigation plans. For example, designating a vulnerable floodplain area for open-space, recreational use, reservoir area or public park can achieve hazard reduction objectives as well as provide a community asset. In this way, basic environmental and social/recreational goals can be combined with those of hazard mitigation. Not only does accomplishing multiple goals through a single initiative protect human lives, the built environment and the natural environment, it also results in more cost-effective government.

Long-Term

To be truly comprehensive, a hazard mitigation plan must have a long-range horizon. While particular plan objectives and specific projects and actions may have a fixed time period within which they are to be achieved or carried out, the scope of the hazard mitigation plan as a whole must be broader than the time frame dictated by individual component parts.

Internally Consistent

It is important that mitigation plans be multi-hazard and multi-objective. However, the pursuit of comprehensiveness should not be undertaken at the expense of internal consistency. Risk reduction measures for one natural hazard must be compatible with risk reduction measures for other probable natural hazards. For example, certain techniques for elevating flood prone structures may make a structure more susceptible to damage from an earthquake. Similarly, retrofitting a building to reduce earthquake damage may be a poor investment if the building is flood prone. On the other hand, tying down a manufactured home can be an effective technique for mitigating wind, flood and seismic hazards.

Furthermore, risk reduction measures for natural hazards must also be compatible with risk reduction measures for technological hazards and vice versa. When hazard mitigation options are considered, care must be taken to avoid solutions that may increase the risk of technological events, such as elevating chemical storage facilities to mitigate flood hazard without addressing seismic risk. Additionally, technological hazards should be minimized for natural hazards, such as using flexible pipes in seismic areas or protecting submerged pipes from flood scour.

Windows of Opportunity

Mitigation plans typically seek to identify the optimum points for implementing mitigation actions within the comprehensive emergency management (CEM) cycle. Strategies for including mitigation as part of the activities carried out during the preparation, response and recovery phases of a disaster are critical for victims of that particular event, as well as help ensure these disaster victims will not be victims again when the next natural hazard occurs.

While mitigative action taken during phases of CEM are significant in reducing potential losses, a truly comprehensive mitigation plan also includes strategies for incorporating mitigation into the day to day operations of the government. The mitigation plan should specify a process for identifying all "windows of opportunity," so that mitigation concepts can be considered when carrying out routine government business. Mitigation should be addressed as an aspect of land use policy, including zoning and subdivision regulations, building inspections, environmental impact review, highway and street planning, capital improvement planning, tax and spending policies and all other relevant activities of government, rather than solely as an issue of emergency management.

The integration of mitigation concepts into the normal function of government is particularly important in the areas of land use law and construction and building regulations. For instance, the government should take care that future land use elements and future land use maps of comprehensive plans include policies for post-disaster density-reduction and land use modifications in areas subject to hazardous conditions. In addition, hazard mitigation planning efforts should be coordinated with enforcement authorities, including land use and construction codes, regulations, ordinances to ensure compliance with mitigation (and therefore public safety) principles. A truly integrative mitigation plan, one that seeks windows of opportunity in all aspects of government operations, can significantly affect a community's future vulnerability to natural hazards. By incorporating mitigation concepts into government activities today at a relatively low cost, we can avoid much more costly losses from future disasters.

Cost-Effective

Every mitigative action proposed in the mitigation plan must address the question of cost-effectiveness: will the proposed measure reduce future disaster response and recovery costs more than the cost of implementing the measure? The hazard mitigation plan should establish in advance the criteria to be used to assess the cost-effectiveness of individual project proposals so that all projects receive uniform objective analysis. Though it is difficult to factor in the monetary value of human life when calculating the cost-effectiveness of a mitigation measure, certain costs can, and must, be examined.

One method is to use the value of the damages suffered in the recent disaster that could have been prevented by a mitigation measure as a basis for comparison against the cost of the proposed measure. Next, the magnitude and probability of the event's recurrence interval should be factored in. If the damages received were from a relatively small, and more frequent, earthquake, hurricane or flood, then it is reasonable to expect that these damages might be repeated several times over the life of a given structure. Thus, a mitigation measure could cost more than the current damages, but still be justifiable. Historical loss data can also be used. For instance, paid insurance claims and previous outlays for disaster assistance should be considered when evaluating cost effectiveness. Normal maintenance costs can be used if the situation is a chronic one. There are also economic and cost-benefit models available that can be used.

Environmentally Sound

The hazard mitigation plan should incorporate environmental principles. Care must be taken that policies intended to foster mitigation are not undertaken at the expense of the area's environmental integrity. The plan should strictly adhere to all applicable laws, regulations and ordinances regarding the environment.

The natural environment can play a crucial role in mitigating the impacts of natural hazards. As the connection between networks of streams, rivers, adjacent wetlands, soils, vegetation, dunes, beaches and other features of the natural environment are increasingly studied and understood, natural resource and environmental management are being recognized as vital for emergency management. This "natural infrastructure" can perform a mitigative function in the human environment, protecting lives and structures from the full impact of natural hazards by providing flood control, wind resistance, minimization of storm surge, etc. The hazard mitigation plan must promote efforts to enhance rather than hinder the mitigative ability of the natural environment before all such areas are developed and their mitigative value destroyed.

Readable

Despite the emphasis on comprehensiveness, if the hazard mitigation plan is to achieve its purpose, it must be a readable document. It must be written in clear unambiguous language so that its intent and direction are obvious. The format of the plan must be straight-forward and simple.

The text of the local hazard mitigation plan must be concise, without minimizing the significance of any one particular segment of the plan. The body of the plan is not to be made up of lists of sources of legal authority, past hazards and disaster figures, or proposed projects and activities. The text should be supported by extensive appendices, where various elements and issues can be described in depth and where data collected for background analyses can be available to support the plan. The plan itself should be an expression of that jurisdiction's approach to hazard mitigation and a description of how, where and when that approach will be carried out.

The plan must speak to the residents, as well as inform government officials of their responsibilities in terms of initiating, implementing and enforcing hazard mitigation measures. Furthermore, the plan must be intelligible to a wider audience than just the residents and officials of the jurisdiction where it applies. The plan may be reviewed and applied by readers who have never visited the area, such as emergency management officials, international aid representatives, charitable organizations and others with an interest in mitigation activities in that area. Often maps, illustrations and other graphics can provide the visual dimension necessary for comprehension of how the plan is to apply in a particular area. Useful maps and graphics could include those showing recommended strategies and project areas, as well as maps indicating which geographic areas are to receive priority attention during plan implementation. Useful background data would include maps depicting flood insurance rates, floodway and flood boundary maps, seismic risk zones, community street and critical facilities maps and land use (current and future) maps.

Types of Plans

Hazard mitigation plans can be one of a wide variety of types of plan; the particular format chosen by a government should best suit the role the hazard mitigation plan is expected to fulfill for that jurisdiction. Some areas may choose to create a hazard mitigation plan that is a stand-alone, single purpose plan. In this instance, care should be taken that all the statutory requirements for plan creation and adoption are followed so that the plan can operate as a freestanding document.

Post-disaster Plans. Governments have traditionally prepared stand-alone mitigation plans in the wake of a disaster, a practice that has the advantage of generating public support for mitigation while the obvious need for it is so readily apparent. Unfortunately, these post-disaster plans are often prepared without adequate background studies and under tremendous time pressures and may not adequately address mitigation issues outside the context of the immediate disaster.

Emergency Management Plan. Other jurisdictions may include the hazard mitigation plan as a component of the emergency management plan. These plans deal with all four components of emergency management and include directions for the government's responsibilities during preparation, response, recovery and mitigation phases. These plans tend to be programmatic in nature and focus on specific courses of action to be taken in the event of a disaster. Emergency management plans can also emphasize policy, however, and provide guidelines for implementing particular plan components.

Comprehensive Plan. Still other areas may decide to make the mitigation plan part of a comprehensive plan. Comprehensive plans tend to have a wider scope than stand-alone plans, setting general principles to guide future activity. This type of plan tends to be policy oriented, and deals with a whole range of issues, including land use, economic development, capital improvements, transportation, housing, natural resource protection and emergency management. Mitigation concepts can either be included in the comprehensive plan as a separate element or chapter or can be incorporated into the other plan components. This latter approach has the advantage of highlighting mitigation as a necessary component of all other government operations and calling for integration of mitigation into day-to-day decision making processes.

Whatever its place in the planning arena, the hazard mitigation plan may be an incremental document that grows and evolves from year to year as the government's experience with hazard mitigation grows and as resources become available. It is not necessary to have a "complete" document that addresses every conceivable aspect of mitigation before a plan is implemented. The plan may be done in pieces, for example, region by region or by type of hazard (*not*, however, by individual disaster). By its very nature planning is a dynamic process, and the plan produced should not be viewed as a static, unchanging document. As the area's needs change, so must its hazard mitigation plan. Despite this inherent dynamism, however, it is vital that in each year, at every point in time, there be a viable approved plan in place, one that is being used day to day throughout the government and in the private sector.

Section IV.
Formulating the Plan

The Planning Process

A hazard mitigation plan can be formulated at any level of government; each jurisdiction must make use of its own unique institutional framework to create its plan. Who is responsible for preparing the plan, who actually writes the plan and who is involved in the formulation process will vary from jurisdiction to jurisdiction, depending upon the anticipated role of the hazard mitigation plan in the area, as well as the financial, technical and political resources that are available.

While there are numerous ways to go about formulating a hazard mitigation plan, certain steps are essential to creation of an effective plan that will allow the government to optimize its use of all the resources at its disposal. The planning process guides the community through its hazard problem(s) by disclosing several options for solving the problems and identifying the most appropriate solutions. It is only by following a proper planning process that the best outcome can be achieved. Basic planning steps include the following:

- Complete background studies: identify and analyze those hazards which affect the planning area, complete an analysis of the probability of those hazards occurring in the area, estimate the vulnerability of the area to those hazards and evaluate the capabilities of the area to effectively mitigate their impacts.
- Draw conclusions about the acceptability of the area's vulnerability to natural hazards and about actions that are being taken to mitigate the effects of natural hazards that affect the area.
- Develop goals and objectives for the hazard mitigation plan.
- Develop policies, programs, actions and strategies to achieve those goals and objectives.
- Consider alternative means to accomplish goals and objectives, then select those that are most appropriate to the jurisdiction.
- Adopt and implement the plan.
- Monitor the plan and continually evaluate its effectiveness and efficiency using a series of indicators and benchmarks.
- Revise and update the hazard mitigation plan at regular intervals.

Some governments may assign responsibility for formulating the hazard mitigation plan to the emergency management division; others may allot the task to the planning department or other agency. Either of these options may involve internal staff writing the plan, or the hiring of an outside consultant to write the plan according to the government's dictates.

Whatever entity or individual is put in charge of plan formulation, it is wise to include a wide range of participants in the planning process. By involving those who will be most affected by the planning, the government will get a more realistic product that will have a much better chance of being adopted and implemented. Departments that should be represented during the planning process include:

- Building department/code enforcement
- Land use planning/zoning
- Emergency management/public safety
- Environmental protection/health
- Engineering
- Public works
- Public information
- Parks/recreation

The private sector should also be involved in the mitigation plan formulation process. Support from the private sector is often essential to successful implementation of mitigation strategies. Involvement of the private sector in the early stages of the planning process may facilitate understanding and support for implementation of mitigation measures. Private sector participants should include realtors, developers, representatives of the insurance industry, builders, architects, investors, farmers, tourists and business leaders. Consolidating private-sector expertise and influence will enable plan-makers to multiply the benefits of mitigation strategies by strengthening the plan's base of support and encourage private sector participants to undertake mitigation measures in their own companies and communities.

Citizen input into the plan formulation process is also essential. Public participation involves including citizen groups in developing mitigation strategy from the beginning. This will help to guarantee that the public is knowledgeable of and committed to the strategy. Some members of the public may even be able to assist with data collection and plan writing, making the planning process more efficient and reflective of local concerns. While government officials will make final policy decisions, citizen participation is designed to give the public the opportunity to voice its views on policy items. The general public often bears the brunt of policies and projects designed to reduce disaster costs and usually at the worst time—after the disaster event. Early public support of the mitigation strategy will also help stem the tide of requests for special exemptions after a disaster.

Basic Studies

Basic studies that must be performed before a mitigation plan can be formulated include identifying and analyzing the hazards which affect the area, assessing the present and future vulnerability of people and property to each type of applicable hazard, performing an assessment of the capability of the area to effectively mitigate those hazards and performing an acceptability analysis to evaluate the likely effects of hazards.

Hazard Identification and Analysis

Prior to formulating a hazard mitigation plan, those hazards that affect the planning area must be identified and the threats that those hazards pose analyzed. Hazard identification and analysis involves determining *what* natural hazards affect the area, the *frequency* or the probability of the occurrence of each of those hazards, the *strength and magnitude* of those hazards when they affect the area, *where* effects are most likely to do the greatest harm to people or damage to property and the *impacts* of each of the natural hazards on the area. The hazard identification and analysis should include a description of *all* the hazards to which a jurisdiction is subject. This step involves gathering and reviewing existing hazard studies. An historic overview of past hazards that have occurred in the area is also useful. Maps that show the hazardous areas within the planning jurisdiction are essential to graphically illustrate the hazards. Plan-makers are encouraged to refer to existing studies that have been conducted with regards to the hazards that are probable in the planning area; often, much of the basic information on hazard identification and analysis is available from regional agencies.

Since the hazard mitigation plan is meant to address the mitigation needs of a specific area, the hazards assessment needs to describe specific hazards and their impact, rather than a broad or generic discussion of the hazard type. For example, while some hazards such as hurricanes have affected an entire island, most hazards are much more limited in the area they affect. Tornadoes generally produce a narrow path of destruction, lightning strikes a particular point, and floods occur in fairly predictable areas. Some natural hazards may have dramatically different impacts at different locations throughout an island.

The hazard description should also include information regarding the typical timing of each type of hazard in the area. Some natural hazards may occur with fairly regular frequency. Given the amount of data accumulated for various hazards, some estimate of the probability of an occurrence of a given type of hazard event is possible. The frequency of occurrence varies greatly by hazard. For example, it is now known that hurricanes follow a cyclic pattern, occurring with greater frequency and at greater strength during an approximate 30–40 year cycle. Earthquake activity tends to occur in extremely long cycles. Lightning and flash flooding, on the other hand, occur with relatively great frequency.

It is also important to assess the strength with which natural events are likely to occur. A relatively strong hurricane will present a greater and more far-reaching series of impacts than those from a relatively weak hurricane. It is important to assess the range of strength of each natural hazard that could affect the planning area, to prepare plans to successfully mitigate the effects across that range.

Finally, it is important to determine the impacts that each natural hazard is likely to have on the planning area. Some hazards may occur in conjunction with, or as a result of, other hazards. For example, heavy rainfall may occur during or following hurricanes and thunderstorms. When planning a mitigation strategy, it is essential to account for the full range of hazard events and effects that may occur.

Although it is impossible to predict precisely what may happen from a particular hazard event, but scenarios likely to result from the occurrence of each hazard should be formulated. Developing scenarios provides a means to understand not only the types of natural hazards that will affect the planning area, but also the potential impacts of those hazards.

When identifying hazards:

- identify all natural hazards which are likely to affect the area;
- define where each hazard is most likely to occur;
- determine where those hazards are most likely to occur within the planning area;
- determine the relative frequency of occurrence of each type of hazard;
- determine the range of strength of the hazard which the planning area is likely to experience.

Probability Analysis

After identifying the hazards that affect the planning area and analyzing the impacts from those hazards, a probability analysis should be undertaken. A probability analysis provides an estimate of the probability of each hazard affecting an area or region, or how likely it is that each type of hazard will occur there.

A chart showing the relative probability from each hazard can be constructed fairly easily. This type of analysis does not necessarily require a detailed quantitative analysis of the probability of each type or hazard event, but can be constructed after careful consideration of the data gathered and analyzed in the preceding step. For example, relative probability from each natural hazard (hurricanes, flooding, thunderstorm, tornado, earthquake, wildfire) can be categorized as low, medium or high. A chart, such as shown below, can be constructed to show the relative probability from all natural hazards under consideration.

Relative Probability of Natural Hazards

Hazard	Low	Moderate	High
Hurricane			
Volcano			
Earthquake			
Wildfire			
Flooding			

To complete this table, it is necessary to select appropriate measures to evaluate the probability from each hazard. Such measures could include:

- the location of the area with respect to exposure to past hazard events;
- the frequency with which each hazard is likely to occur in the area, based on historical records and trends;
- the relative strength of a typical hazard event which has affected the area.

For instance, island areas are known to experience hurricanes fairly regularly, at least once every eight to nine years, on average. This would place most coastal areas at relatively high probability of a hurricane hazard event. Similar evaluations of the likelihood of occurrence of each type of hazard in the planning locality could be constructed. Obviously, not all areas will be exposed to all of the hazards listed. However, careful evaluation may uncover probability to hazards which has not been evident previously.

Complete the table by determining the appropriate category for each hazard. Once this process has been completed, those hazards that pose the greatest relative threat will be evident. This will enable hazard mitigation efforts to be targeted to those hazards that pose the greatest threat to the area.

In summary, to assess probability, it is important to:

- determine the likelihood of each natural hazard occurring in the planning area; and
- construct a table showing the relative probability from each type of natural hazard.

Vulnerability Analysis

Hazards are natural occurrences. A hazard area may or may not pose problems to people; a hazard area is only a problem when human activity gets in the way of the impacts that occur as a matter of course during and after a hazard. *Vulnerability* to a natural hazard can be defined as the extent to which people will experience harm and property will be damaged from that hazard. Natural hazards impact human and animal life, real and personal property, communications and transportation networks and the social fabric of communities and regions. Hazards may result in loss of life or injury to people and livestock; loss of or damage to homes, businesses and industries; loss or damage to automobiles, furnishings, records and documents; damages or interruptions to power and telephone lines, damage or closing of roads, railroads, airports and waterways; and general disruption of life.

Vulnerability to natural hazards exists both at the present time and in the future. The present level of development and infrastructure generates a set of conditions that result in every area having some degree of vulnerability to natural hazards. That degree of vulnerability will change in the future as an area experiences greater development and/or implements greater hazard mitigation efforts. Vulnerability can increase or decrease in the future. Therefore, we can speak of both *present vulnerability* and *future vulnerability*. Each of these types of vulnerability to natural hazards will be detailed below.

Present Vulnerability

Present vulnerability can be defined as the degree of harm to people and damage to property an area may experience from a natural hazard occurrence today. This vulnerability is determined as a result of the likelihood of various types of hazards affecting the area and the current development of that area. Current development affects an area's vulnerability in the following ways:

- the population of the area: the greater the population, particularly in locations susceptible to impacts from hazard events, the greater the vulnerability due to injury to and loss of life;
- the amount and type of development in the area: the greater and the more dense development is, the greater the vulnerability due to loss and damage to property;
- the communications networks in the area: the greater the number of communications networks, and the more sophisticated the equipment involved in those networks, the greater the vulnerability due to loss of communications and interruptions of services;
- the transportation and utility networks in the area: the greater the volume of people and goods transported through the area, the greater the vulnerability due to the interruption of travel and loss of infrastructure. Also, the more dependent an area is on a single transportation or utility line, the greater the vulnerability due to lack of parallel backup lines which can be used.

Assessing present vulnerability can be complex task. However, it is not necessary to perform a detailed quantitative analysis of the number of people who live in a hazard area or the exact dollar value of real property that may be damaged or destroyed in a particular area. A qualitative analysis using a few indicators can serve as an effective means of developing a vulnerability assessment. An indication of the assessed value of property in an area may be gained quickly by examining tax base valuation maps on Geographic Information System (GIS) files, if available.

Other, less exact means, may also be used to gauge an area's vulnerability to natural hazards. For example, vulnerability to tornadoes could be calculated as the result of the interaction of several factors. One factor would be the relative risk of experiencing a tornado. This could be determined by the number of tornadoes that have occurred in an area over a period of time. Another factor would be the population density of the area. Instead of using exact figures, the population density could be classified according to relative terms such as very high, high, average, below average, or much below average. These factors could be combined to produce a relative measure of vulnerability.

Data useful in performing this type of analysis include:

- historical or average frequency of each type of hazard event;
- population of the area, including seasonal fluctuations, if applicable;
- number of people or properties particularly susceptible to damage from each type of hazard event;
- special communications, transportation or utility facilities, which could sustain crippling damage from a hazard event;

- unique circumstances which may increase or decrease the planning area’s susceptibility to harm or damage from a hazard event; and
- the degree of local mitigation efforts already in place for a given natural hazard.

A chart can be constructed to show relative present vulnerability to each natural hazard. The process is similar to that used in constructing the previous chart for probability assessment. The chart will serve to demonstrate the planners’ assessment of the relative vulnerability to each hazard in a qualitative, rather than a quantitative, sense. This chart will identify those hazards to which the area has the greatest present vulnerability. This will enable hazard mitigation efforts to be targeted to those hazards to which the area has the greatest vulnerability. An example is shown below.

Relative Present Vulnerability to Natural Hazards

Present Vulnerability			
Hurricane	**Low**	**Moderate**	**High**
Hurricane			
Volcano			
Earthquake			
Wildfire			
Flooding			

Future Vulnerability

Future vulnerability can be thought of as a measure of the extent to which people will experience harm and property would be damaged by a hazard event if a projected scenario of development were to occur.

An area’s vulnerability will change with time. For instance, if current development patterns are projected into the future, it is possible to develop estimates of the population and amount of development that will exist in an area at some future point. If an area’s population is currently growing at the rate of five percent, it is possible to project the population five or ten years in the future. If current development patterns were assumed to continue, the number of additional housing units, commercial establishments and businesses could also be projected for similar time periods. Transportation, utility and communications infrastructure is likely to increase also. Thus, given an increasing population and increasing development, it might appear that an area would have a greater vulnerability to hazards in the future.

Vulnerability will increase markedly if development occurs in areas particularly susceptible to adverse impacts from natural hazards and/or without the presence of effective mitigation measures. For example, in the absence of effective hurricane standards in an official building code, an area's vulnerability to hurricane hazard may increase dramatically, even if development is limited to those areas considered at relatively low risk to hurricane occurrence.

Planning for redevelopment in the wake of a natural disaster can also reduce an area's future vulnerability. Plans should be formulated that would allow and encourage redevelopment in a manner which would result in a lower vulnerability in the future, i.e., plans should be made that would allow for the correction of what may be considered current development "mistakes" from a hazard mitigation perspective.

Therefore, the future vulnerability of an area is strongly influenced by that area's choices of the amount, type and location of development and transportation and communications links. Careful planning can help avoid a dramatic increase in future vulnerability. Likewise, implementing hazard mitigation measures can result in a decrease in future vulnerability. Planning and mitigation are the keys to successfully managing future hazard vulnerability.

In assessing vulnerability, it is important to look not only at the immediate area, but also to the surrounding region, to account for factors that could have an impact from outside the jurisdiction. For instance, some areas have implemented flood control measures such as dams or stream channelization. Those measures may serve to mitigate the effects from hazards in that particular area, however, those measures may create adverse impacts on others. For instance stream channelization may mitigate against flooding in the immediate area but cause increased flooding to downstream areas due to the increased stream flow and increased velocity of the channeled flood runoff.

Relative Future Vulnerability to Natural Hazards

Future Vulnerability			
Hazard	**Low**	**Moderate**	**High**
Hurricane			
Volcano			
Earthquake			
Wildfire			
Flooding			

Capability Assessment

The capability assessment describes the legal authority vested in the government to pursue measures to mitigate the impact of natural hazards. This section describes how the capability assessment should also be used to evaluate the area's political willpower, institutional framework, technical know-how and ability to pay for mitigation. The capability of all levels of government, as well as the contributions made by non-governmental organizations (churches, charities, community relief funds, the Red Cross, hospitals, for profit and non-profit businesses) and by the private sector should be included, with a description of their utility to the jurisdiction in terms of hazard mitigation. In other words, before formulating the plan itself, it is important to understand the status of current policy and practice and how mitigation programs and activities that will be proposed in the hazard mitigation plan will fit into the existing systems.

However, the capability assessment is more than a mere inventory of existing mitigation measures and organizations with hazard mitigation responsibility. The capability section is an important component of the mitigation plan because it identifies and evaluates existing systems that either reduce or increase a jurisdiction's vulnerability to natural hazards. This includes evaluation of the "de facto" mitigative measures—those which may be designed for another purpose, but which, nevertheless, have an effect (either positive or negative) on mitigation. The capability assessment can, therefore, provide a mechanism to cite and take credit for those systems that exist and are working to reduce hazard vulnerability (whether such measures were designed for hazard mitigation purposes or not). This list of "success stories" helps avoid duplication of effort when new systems and programs are recommended. It is also important when disaster assistance agencies are assessing the area's past performance for purposes of granting disaster relief funds.

Legal Capability

Governments of different countries and different levels of government within one country operate under different sources of authority. However, as a general rule, with proper enabling legislation in place, most governments possess the power to engage in various hazard mitigation activities. The capability section of the hazard mitigation plan should analyze each of the legal powers available to that particular government to identify which can be wielded to craft hazard mitigation measures and also assess legislation that may impose limits on certain mitigation efforts.

Within the limits set by each country's legal system, most government powers fall into one of four basic groups (although some governmental activities may be classified as more than one type of power): regulation, acquisition, taxation and spending. Hazard mitigation measures can be carried out under each of the four types of powers, as described below:

Regulation. Governments are generally granted broad regulatory powers in their jurisdictions, enabling the enactment and enforcement of ordinances to regulate or prohibit conditions or actions that may endanger the public's health and safety. Such authority is known generally as the "police power," and encompasses the concept of hazard mitigation as a means of protecting the public.

One important regulatory power exercised by some governments is that of building inspection. Typically, such legislation deals with the construction of buildings, installation of plumbing, electrical and heating systems, building maintenance and other matters. Through this type of regulation, the government can be directly involved in reducing the community's vulnerability by requiring that all new construction comply to strict mitigation standards.

Typically, regulatory powers are also the most basic manner in which a government can control the use of land within its jurisdiction. Through various land use regulatory powers, a government can control the amount, timing, density, quality and location of new development; all these characteristics of growth can determine the level of vulnerability of the community in the event of a natural hazard. Land use regulatory powers include the power to engage in planning, enact and enforce zoning ordinances, floodplain and subdivision controls, as well as regulate other aspects of growth. Carefully planned and executed land use regulations can be effective in preventing unsuitable development from occurring in hazard-prone areas.

Acquisition. The power of acquisition can be a useful tool for pursuing mitigation goals. Governments may find the most effective method for completely “hazard-proofing” a particular piece of property or area is to acquire the property, thus removing the land from the private market and eliminating or reducing the possibility of inappropriate development occurring. Legislation typically empowers units of government to acquire property for public purpose by gift, grant, devise, bequest, exchange, purchase, lease, or eminent domain. The local government may acquire the hazard-prone property in fee, or may obtain a lesser interest in the land, such as an easement to keep the land in a natural state. Some communities may also employ a transfer of development rights (TDR) program to keep hazardous land free from development while allowing other, more appropriate real estate to be developed at a higher density than is usually permitted.

Taxation. The power to levy taxes and special assessments is an important tool delegated to most governments. While taxes and special assessments can be an important source of revenue for governments to pay for mitigation activities, it is also important to note that the power of taxation can have a profound impact on the pattern of development in the community. Many jurisdictions set preferential tax rates for areas that are unsuitable for development (e.g., agricultural land, wetlands); such special rates can be used to discourage development in hazardous areas.

Spending. Spending is the fourth major power available to governments that can have an impact on the vulnerability of the community. Hazard mitigation principles should be made a routine part of all spending decisions made by all levels of government, including annual budgets and capital improvement plans.

A capital improvement plan is usually a timetable by which a unit of government indicates the timing and level of government services it intends to provide over a specified duration. Capital programming, by itself, can be used as a growth management technique, with a view to hazard mitigation. By tentatively committing itself to a timetable for the provision of capital to extend government services (in particular, water and sewage disposal), a government can control the growth in its area to some extent.

Institutional Capability

The capability of the government to develop and implement a hazard mitigation program is affected by the institutional framework in which it will operate. Therefore, a description of the type of government, including an “inventory” of key decision-making positions, both long-range and day-to-day is an essential component of the hazard mitigation plan’s capability assessment. The analysis should include all relevant governmental agencies, departments and offices with responsibility for the various stages of emergency management (preparation, response and recovery) as well as for mitigation. The responsibilities of both elected and appointed officials, as well as career governmental workers should be noted. The assessment should specify who is responsible for police, fire, garbage, roads, parks, planning, zoning, building code enforcement, tax assessments, water and sewer, and other services. The capability section should also analyze local, national and regional government relationships and identify opportunities for cooperation and optimization of pooled resources.

Political Capability
The capability of a government is obviously linked to its political capability. Many of the activities carried out by the officials listed in the institutional framework analysis will be politicians, whose decisions are sometimes swayed by the political climate of the moment rather than by the long-range benefit to the community. Analyzing how mitigation can be inserted into everyday decision-making as a routine course can go a long way to de-politicizing the issue. If mitigation comes to the forefront of the government's important issues, politicians cannot do otherwise than promote mitigation. Public education and awareness campaigns about the economic efficiency of mitigative measures in the long run can help foster its general acceptance by citizens and in turn by politicians.

Fiscal Capability
While the power to levy property taxes and special assessments to issue bonds are effective for raising revenue in some jurisdictions, the amount needed for development of a local hazard mitigation program will generally need supplementation from other sources. Foreign aid in the form of grants and loans are available to some degree for hazard mitigation purposes. In addition, charitable, environmental, volunteer groups and other non-profit organizations are often willing to contribute where a need is perceived as significant. Private industry, investors and the business community should also be included as potential sources of fiscal aid, perhaps with an incentive to participate.

Technical Capability
If the concept of hazard mitigation is being introduced to an area for the first time, or if a more experienced jurisdiction wishes to upgrade its level of mitigation, technical know-how may be at a premium. Often a major impediment to effective emergency management policies and programs, including mitigation, is the lack of technical expertise. Communities are faced with the task of identifying and assessing hazards, predicting the occurrence of disasters, gauging the level of intervention needed and designing and implementing effective measures. Fortunately, there are many manuals and other documents available that can be used to help identify and assess various hazards. Technical manuals are also available that detail the forces that mitigation techniques are engineered to withstand, construction methods, costs (complete with formulas to make adjustments to current values), options and alternatives, cost/benefits, the pros and cons of each technique and even suggestions on how they can be financed, adopted or implemented.

Analysis and Evaluation of Capability Data
After gathering capability information, the data must be analyzed and evaluated. Since the capability assessment will provide the framework for developing recommendations for specific mitigative actions in the hazard mitigation plan, it is essential that the assessment both identify shortfalls in a jurisdiction's capability, as well as draw attention to special opportunities that should be capitalized upon while they remain viable.

By referring to the capability assessment, the government will be able to rank all recommended activities according to the capability of the area to actually institute them. The proposed activities must be evaluated against the backdrop of what is feasible in terms of that government's legal, institutional, political, fiscal and technical capacity. Proposed activities should be classified as those which (1) can be carried out easily, without a change in the law; (2) require only a change in the regulations; (3) can be implemented with only a change in practice; (4) require new authorization.

Conclusions (Acceptability)

An *acceptability assessment* is a useful analytical step that can help prioritize and focus limited resources on the most critical of its mitigation needs. The government may wish to include documentation of this assessment in an appendix to the hazard mitigation plan. The purpose of developing and evaluating conclusions, sometimes referred to as an acceptability assessment, is to determine whether additional hazard mitigation efforts should be undertaken and, if so, which hazards, geographic areas and response capabilities will be strengthened. A determination can be made of where to target mitigation efforts by reviewing which natural hazards pose the greatest risk to the area, the hazards to which the area is now and/or will be particularly vulnerable, and the present and future capabilities to respond to those hazards. Targeting mitigation to those hazards to which the area is, or is expected to be, most vulnerable and to which the area has a need for increased response capability will enable limited financial, personnel and material resources to mitigate the most severe hazards, risks and capability deficiencies. An area's risk and vulnerability to natural hazards cannot be eliminated, but can be limited through carefully planned mitigation strategies.

The probability, vulnerability and capability analyses that have been completed provide an indication of the potential amounts, locations and types or damages from hazards and the jurisdiction’s capability to respond to those hazards. Officials and planners must now decide if it is necessary to increase the area's ability to reduce its vulnerability to threats from natural hazards.

The following chart shows how the previously completed analyses of risk, present and future vulnerability and present and future capability may be used to generate conclusions, or complete an acceptability assessment. The spaces under risk, vulnerability and capability should be completed from the evaluations made in previous steps. Based on the evaluations of risk, vulnerability and capability, the planner should be able to generate a similar relative indication of the acceptability of each type of natural hazard.

Summary Chart to Determine Acceptability/Conclusions

Hazard	Probability	Vulnerability		Capability		Acceptability/ Conclusions
		Present	Future	Present	Future	
Hurricanes						
Volcanoes						
Earthquake						
Wildfire						
Flooding						
Other						

For example, assume that the analysis thus far has determined that hurricanes pose a high risk to the planning area, that the present vulnerability is moderate, the future vulnerability is likely to be high, the present capability is moderate and that the future capability is likely to be low. The acceptability would likely be low or moderate, because this scenario shows conditions worsening and capability decreasing for a hazard with a high likelihood for causing harm and damage. In another example, assume that analyses have determined that earthquake pose low risk, the present vulnerability is moderate, the future vulnerability is likely to remain moderate, the present capability is moderate and will likely remain at that level in the future. In this case, the area's acceptability would probably be determined to be moderate to high.

In short, by reading across the rows for each hazard, planners come to an assessment of where the planning area lies in terms of *each* hazard. The planner can now make a judgment of that position, i.e., is that an acceptable situation for the area? In some cases, the answer may be “yes,” in other cases, the answer is likely to be “no.” If the answer is “yes” then there is no need to implement additional mitigation measures for that hazard at that time. However, the acceptability should be reviewed periodically as it may change with time. If the answer is “no,” then the mitigation plan will need to develop goals, objectives and policies and actions to improve the situation to an acceptable point.

By completing this type of analysis for each hazard, the result will be a chart that provides an indication of the relative acceptability of the situation with regard to each hazard that is likely to affect the area. This analysis should be repeated for each major area in the jurisdiction, since conditions will vary throughout the planning area according to localized conditions. This analysis will then allow officials and planners to design a hazard mitigation plan to effectively increase the area's capability to respond to the hazards which have the greatest effect and to undertake actions to decrease the effects of those hazards to which the area is most vulnerable.

With regard to each type of natural hazard, possible actions range from doing nothing to an attempt to completely eliminate potential damages to life and property. In most instances, officials will decide to undertake some mitigation measures. That strategy will usually be determined as a result of the conditions present and likely to develop in the area and the human, financial and physical resources available now and expected to exist in the future.

This step requires judgment. There is no single “right” decision or strategy. The initial mitigation decision or strategy will also need to be reviewed periodically, to stay abreast of changing conditions. The important thing is to make a series of informed hazard mitigation decisions and use these as a basis for action.

Conclusions act as a bridge between gathering information about existing and future conditions and capabilities and developing a local hazard mitigation plan. This stage of planning involves a critical assessment of the hazards that affect the planning area, the locality's capability to mitigate those hazards and changes desired in hazard mitigation efforts.

Rationale

When formulating the rationale section of the hazard mitigation plan, plan-makers will draw on *all* of the accumulated information contained in the basic studies. It is the resulting knowledge emanating from these studies that establishes the need for the existence of the mitigation plan. The plan should refer directly to the types of hazards to which the planning area is subject, their probability and magnitude and the level of vulnerability of the people and the built environment to these hazards. The plan should also refer to the current and/or future capabilities of the jurisdiction to mitigate the impacts of these hazards. The introduction to the hazard mitigation plan should also include a definition section and include all terms and phrases dealing with hazards, mitigation, emergency management, disaster relief, planning, government and law. This will help avoid confusion and misinterpretation based on divergent meanings of words.

The rationale section should clearly indicate that the plan is an expression of the government’s commitment to mitigation goals, objectives, policies and programs and that the plan’s mission is to coordinate multiple goals, objectives, policies and programs to the greatest extent practicable.

The introduction to the hazard mitigation plan also provides an opportunity for the government to establish the connection between the public interest and the mitigation goals, objectives, policies and programs outlined in the plan. The rationale section should also emphasize the utility of the hazard mitigation plan as an information vehicle, to educate the public and private sectors and policy-makers about natural hazards and about mitigation.

Goals

Goals are statements of desirable future conditions that are to be achieved. Goals should be expressed in general terms and are usually descriptive rather than quantified statements. A goal is a desirable condition that is valued for itself; a goal is not an instrument to achieve something else. Goals should be structured as positive statements that are attainable rather than negative observations about the planning area.

Goals may originate from several sources. These sources include:

- community concerns and desires, reflecting a participatory goal setting process;
- needs for accommodating change such as increased population and development and adjustments to infrastructure;
- good mitigation and planning philosophy and practices. These goals could include equity of costs and benefits, protection of constitutional rights, protection of environmental quality, public health and safety and quality of life;
- mandates from governmental legislation, rules and guidelines and from judicial interpretation of statutes and regulations; and
- previously adopted government policies which may be contained in current ordinances and plans.

Goals may be developed for different purposes. For example, sets of goals may be developed for mitigating existing conditions, for guiding future development so that vulnerability does not increase dramatically in the future and for expanding the area's capability to mitigate hazards in the future.

Goals should be developed on a case by case basis for each planning area to reflect local conditions, needs and desires. Hazard mitigation planning goals could include:

- *to manage development so the locality's future vulnerability does not exceed its present degree of vulnerability natural hazards.*
- *to enable all residents to safely evacuate the area if faced by a hurricane threat.*
- *to improve communications capability between various government agencies and personnel.*

Goals should also be cross-cutting in areas of public interest in addition to hazard mitigation. For instance, hazard mitigation plan goals can support such principles as improving water quality, sustaining farmland, preserving natural areas, etc.

Objectives

Objectives provide intermediate steps toward achieving a goal. Objectives are more tangible and specific than goals and may be quantified. It may be easiest to think of objectives as a progression of steps toward a goal. Objectives may be used as a checklist. When an objective is accomplished, it may be checked off and progress oriented toward accomplishing another objective. Whereas goals are general statements that may never be fully realized, objectives should be capable of being realized. Typically, several objectives are identified for each goal that is developed.

To continue with one example used above, consider the goal of restricting future vulnerability to hurricane threat to the level of present vulnerability. Objectives to accomplish that goal might include some of the following:

- revising local building and development ordinances to require construction practices which have been determined to result in decreased damages from hurricanes;

- prohibiting development in areas particularly vulnerable to storm surge, high winds and flooding; and
- tying new development to provision of additional highway travel lanes, to maintain a particular level of emergency evacuation capacity.

Objectives can and should be structured so that they serve multiple community interests. The objective of prohibiting development in high hazard areas, for instance, accomplishes the goal of restricting future vulnerability as well as preserving natural areas.

Alternative Means to Accomplish Goals and Objectives

In most cases there is not a single means to best accomplish goals and objectives of a mitigation plan. There may be several methods to accomplish a given end. Some methods may involve a high financial cost, other methods may require great use of volunteer contributions of time and effort. Still other methods may require a high degree of intergovernmental cooperation. There is no one method that can be applied universally. Therefore, each mitigation plan will have to develop and evaluate a unique series of actions and policies to implement its plan and accomplish its goals.

Communities should carefully explore *all* available alternatives to determine those which will work best for that particular area. A series of brainstorming sessions may be necessary to gather a wide range of possibilities. Weigh area needs, capabilities, commitments of financial, personnel and material resources and decide on the best methods to use to accomplish the objectives. Discuss the potential methods with everyone involved in the mitigation planning effort. In this way, not only will a consensus of opinion develop, there will also be a sense of ownership of the plan by all the stakeholders involved in developing, implementing and contributing to the plan.

Each possible mitigation measure should be reviewed, and all options should be listed in an appendix to the plan. The appendix should also include a description of the criteria used to select the alternatives that will be made a part of the plan. According to the criteria, some alternatives may not be practical or appropriate; others may be unacceptable in the community. This too should be noted in the appendix. Possible questions to raise to evaluate mitigation alternatives include the following:

- Is the measure technically appropriate for the particular hazard for which it is proposed?
- Does the measure support or hinder any of the plan’s goals or objectives?
- Do the measure’s benefits equal or exceed its cost?
- Is it affordable?
- Is there available funding?
- Will it comply with all local state and federal regulations?
- Does it have a beneficial or neutral impact on the environment?

When developing alternative means to accomplish goals and objectives, several windows of opportunity should be considered. There are many different times at which hazard mitigation efforts can be integrated with other community planning and development activities. Some windows of opportunity occur in day-to-day activities, projects, preparation for hazard events, response to hazard events and recovery efforts. A chart like the one that follows can be an integral part of determining such windows of opportunity. By identifying opportunities in this manner, officials and planners can make maximum use of *all* potential mitigation opportunities.

Develop appropriate means of mitigating each of the different natural hazards under each window of opportunity. Concentrate on developing strategies to mitigate those hazards that pose the greatest risk to the planning area, to which the area is most vulnerable and to which your response capability is in need of greatest improvement.

Means of Achieving Goals and Objectives

Hazard	**Windows of Opportunity**				
	Day-to-Day Activities	**Projects**	**Preparation**	**Response**	**Recovery**
Hurricanes: Present					
Future					
Volcano: Present					
Future					
Earthquake: Present					
Future					
Wildfire: Present					
Future					
Flooding: Present					
Future					

When considering day to day activities, the window of opportunity is *always* open, except during hazard events. Typical actions that could be included in this category would be administration of the building or development code, keeping drainage ditches clear of debris and ensuring emergency communication devices are in proper working order.

When considering projects, the primary question to address is: how will this project affect the future vulnerability of the locality? Projects are most effective if they will result in a reduction of vulnerability to hazard events in the future. Examples of this type of action include siting public structures in areas with a relatively low vulnerability to natural hazards, promoting the use of underground utility lines in new development, stabilization of sand dunes in coastal areas.

Preparation activities involve at least two types of activities. Structural activities include actions to prepare for the imminent arrival of a hazard event, such as putting up storm shutters and sandbagging. Non-structural activities involve taking steps to minimize damage to personal property and to minimize harm to individuals. For instance, anchoring boats and storing yard furniture in sheds prior to the arrival of a hurricane will lessen the chance of damage to personal property. Following recommendations to evacuate an area will lessen the chance of harm to individuals.

Response activities are those actions that occur during or immediately following the hazard event. While these actions may be planned events, specific actions will depend on the severity, location, effects and details of a particular hazard event. Response activities are those practiced during emergency preparedness for recovery actions during this time.

Recovery activities are those activities that take place in the aftermath of a hazard event. Years of natural hazard disasters have demonstrated that it is easy to implement many ad hoc projects whose sum is less than the total of their parts because of a lack of a comprehensive plan of action. If a comprehensive mitigation strategy has been developed slowly, building on a series of day-to-day activities to create a deliberate plan, recovery efforts may result in achieving not only immediate restoration of normal activity in the area, but also changes to procedures which will result in a reduction of the vulnerability of the area to and an increase in its capability to deal with, future hazard events.

Plans, Policies and Programs

Once goals have been developed and objectives for each goal have been identified, then plans, policies and programs may be developed and implemented, drawing on the alternatives for achieving goals and objectives that had previously been analyzed and found feasible. The selected measures should appear in the plan itself; in fact, this is the heart of any plan that is meant to do something. Research has provided the knowledge to develop a broad spectrum of mitigation measures that can reduce the impact of natural disasters on the built environment. These actions include both structural and non-structural mitigation, such as land use planning and management, engineering, building standards, codes and practices and insurance. Select those alternatives judged most effective in terms of mitigation multiple hazards and accomplishing multiple objectives. Not all mitigation efforts will be able to accomplish multiple objectives; the idea is to try to maximize the effects of those strategies and actions that are undertaken by all localities.

Policies. Policies are principles of hazard mitigation, derived from goals, but targeted more directly at what the government can do to attain its goals. Policies are typically stated as actions, using verbs, rather than simply statements of goals or objectives. Policies can be classified as either avoidance or resilience, depending upon the result they are designed to achieve. Avoidance policies are those that are intended to remove at-risk structures from the line of danger, so that the impact of a natural hazard is avoided. Resilience policies call for activities that make buildings better able to withstand the impact of natural hazards. Policies may be adopted in a wide range of planning areas, including:

- growth and/or development management—where and how growth and development will be encouraged or discouraged to take place, to best serve mitigation efforts;
- environmental protection—what critical environmental areas merit special protection from development, to reduce future vulnerability to natural hazards;
- fiscal—how will the costs of mitigation strategies be distributed among various populations, including existing residents, future residents, those moving to the area, landowners, industry, etc.;
- transportation—where should transportation improvements be implemented to enhance the ability to mitigate hazards. For example, what highways should be targeted for increased capacity to allow for quicker evacuation from areas at high risk to flooding;
- communications—how should private and public development be coordinated to assure that an effective communications network is developed and implemented to assure communication between local and state officials and the public during hazard events; and
- the planning process—what time frame(s) will be adopted for accomplishing specific actions, what should be the degree of public involvement in the planning process, how could local efforts be coordinated into regional mitigation efforts in the future.

Programs and Plans. Programs and plans of action are the heart of any plan. These are made up of strategies that have been developed as specific methods to accomplish goals and objectives. The following programs could be incorporated into a comprehensive natural hazard mitigation plan:

- A program of recommendations for changes to local development codes to lessen damage from natural hazard events which impact the area. Such recommendations might include changes to existing subdivision, zoning and other development regulations, or recommendations for adoption of a newly developed unified code guiding development. Recommendations could address hazard mitigation measures to be required as part of development approval; procedures for reviewing and approving development permit applications; tailoring standards for the type, density and allowable impacts of development to the sensitivity of the proposed development location; site plan and construction practice requirements, perhaps incorporating performance standards and possibly requirements for exactions and impact fees, to encourage particular types, site designs and construction practices of development to achieve development that will not increase the area's future vulnerability to natural hazards.
- An infrastructure program, specifying the locations, sequence, timing and distribution of improvements and additions to transportation, utility and communications networks to

assist in mitigating the effects of hazards and reduce future vulnerability to such hazards. Recommendations developed as part of this program should be integrated into local capital improvement plans for transportation and communication facilities and protection of critical environmental areas.

- A program to acquire property rights to critical pieces of property either in fee simple or through easements to protect sensitive areas from development and to prevent a dramatic increase in the area's future vulnerability. This program should also be integrated into the local public sector investment plan.
- A program to increase local capability to respond to natural hazard events. Such programs could include training activities, increased preparedness planning actions and preparation of a multi-year budget for acquiring equipment used in mitigation efforts.

A successful hazard mitigation plan should specify content, geographic coverages, timing, assignment of responsibility and coordination of the various parts of the plan. Content involves a statement of pertinent regulations and other exercises of governmental power, such as taxation and fees, or acquisition, which will be used to achieve the desired results. Plans may adopt strategies to control the rate of growth in environmentally sensitive areas, or areas with limited evacuation capability, delineating preferred growth areas and development of small area plans for special environmental areas.

The geographic coverage of the plan should include maps showing locations of proposed infrastructure improvements or expansions, areas where different impact fees or service fees apply, areas where restrictions apply, such as floodplains or conservation zones; and areas where incentives apply, such as receiving zones for transfer of development rights.

Timing balances the desired effects of the pace and location of development with limitations of governmental resources. For example, a timing strategy might propose that the simpler, more vital and more complementary mitigation measures be adopted and implemented first.

Responsibility must be designated for designing specific standards and procedures, overseeing adoption and implementation of policies and programs. The lead agency for each program or action should be specified and shared responsibilities should be stated explicitly.

The hazard analysis and alternative means to achieve goals and objectives that were completed earlier should feed into your decisions when formulating the plans, policies and programs section of the hazard mitigation plan. For instance, hazards which were identified as posing a low risk would not be addressed by many, if any, actions. Hazards which pose a high risk, to which the area is particularly vulnerable, or with which the area has little capability, would receive the greatest attention and would generate the greatest number of activities to be accomplished. All too often, immediate restorative actions take place following a severe hazard event. Rather than *react* to an event, planners and officials should proactively *plan* for all hazards that are likely to affect the area. Mitigation efforts should not be targeted to a specific event; rather, mitigation strategies and actions should improve the jurisdiction's capability to respond to related events.

Section V.
Adoption, Implementation, Monitoring and Evaluation

To be enforceable policy, a local hazard mitigation plan must be adopted by the legislative body of the government. A series of recommendations made by planning staff would not have nearly the impact as will an official document that lays out the government's policies regarding mitigation. The plan should be adopted according to the custom and laws for passing all such legal devices in that jurisdiction.

After a hazard mitigation plan has been developed and adopted, it is important to continually track the progress of mitigation actions and evaluate how the proposals contained in the plan work in practice. Planners and other officials involved in hazard mitigation must monitor the implementation of the plan and evaluate its effectiveness, to recommend additional mitigation actions and make periodic revisions to the plan.

Monitoring and evaluation are the ongoing processes of compiling information on the outcomes resulting from implementation of a hazard mitigation plan. This process measures progress in achieving goals, objectives and policies. Through the monitoring and evaluation process, revisions needed to respond to changes in regional and local conditions may be identified. Planning conditions are constantly changing; mitigation plans must also change in response to changes brought about through increased development, changes in technology and changes in mitigation capability.

The primary question to be addressed in monitoring and evaluating hazard mitigation plans is: has the area’s vulnerability increased or decreased as a result of planning and mitigation efforts? Where vulnerability has decreased, planners should determine if other methods could be used to achieve even greater improvement in reducing the area’s vulnerability. Where vulnerability has increased, or has not decreased as projected, mitigation efforts must be evaluated to determine if other mitigation strategies might provide greater effectiveness than those currently in use.

In designing a monitoring and evaluation system, select the plan objectives that will be tracked. Those objectives should include indicators that will track mitigation efforts that have the greatest importance. Since most localities will be unable to monitor all hazard mitigation efforts, high priority objectives should be identified. These objectives should include the more important mitigation programs, programs that mitigate hazards that occur with the greatest frequency and programs which have lower confidence in the certainty of outcomes. Programs that have less certain outcomes should be tracked carefully to determine if the outcome is indeed similar to that which was predicted. If the outcome is different than that predicted, the program should be evaluated and altered as necessary.

Section VI.
Revisions and Updates

A hazard mitigation plan should be revised whenever a flaw is detected and updated on a regular basis. Revisions are necessary to correct flaws that are discovered in the plan. No plan, however perfect in concept, will be perfect in execution. There are always some contingencies that cannot be foreseen, or events that cannot be predicted. Revisions will make changes necessary to better fit the plan to real-life situations.

Updates address changes which have taken place in the planning area. Changes may result from additional development, implementation of mitigation efforts, development of new mitigation processes and changes to statutes and regulations. Additional development in an area may result in an increase, little change, or a decrease in that area's vulnerability to natural hazards depending on the location, type and design of that development.

Implementation of mitigation efforts should result in a decrease of an area's vulnerability to natural hazards, but this decrease should be evaluated relative to other changes that may have increased vulnerability. On balance, have mitigation efforts resulted in an overall decrease in vulnerability, or have those efforts been overshadowed by changes that have produced a net increase in vulnerability. Natural hazard mitigation is evolving. Mitigation programs and strategies are under continuous development and refinement. Periodic revision of mitigation plans will help to insure that local mitigation efforts include the latest and most effective mitigation programs and strategies.

There is not one specific interval that can be recommended for updating every hazard mitigation plan. Updates to a mitigation plan will be subject to availability of resources. Some localities have more personnel, financial and technical resources available for planning than others. Some areas are subject to more frequent and/or more damaging hazards than others.

Caribbean Disaster Mitigation Project

The Caribbean Disaster Mitigation Project (CDMP) is a coordinated effort to promote the adoption of natural disaster mitigation and preparedness practices by both the public and private sectors in the Caribbean region through a series of activities carried out over a five-year period. The CDMP is funded by the USAID Office of Foreign Disaster Assistance (OFDA) and implemented by the Organization of American States/Unit of Sustainable Development and Environment (OAS/USDE) for the USAID Caribbean Regional Program (USAID/CRP).

The CDMP provides a framework for collaboration with the Caribbean region to establish sustainable public and private sector mechanisms for natural disaster mitigation that will measurably lessen loss of life, reduce the potential for physical and economic damage, and shorten the disaster recovery period over the long term. Project activities vary according to location, contents and implementation strategy, but all contribute to attainment of the overall CDMP goal: a more disaster-resistant environment for the people who live, work and invest in this hazard-prone region.

Project activities include: 1) natural hazard risk audits for electrical utilities and other infrastructure systems and key lifeline facilities; 2) hazard mapping to support improved planning and location of physical development; 3) promotion of loss reduction incentives and hazard mitigation in the property insurance industry; 4) assisting countries to adopt improved building standards and practices and training of builders, architects and artisans in their use; 5) stimulating community-based disaster preparedness and mitigation efforts with support of the private sector, and, 6) post disaster mitigation planning and program design.

The CDMP will build on past and ongoing regional initiatives in disaster preparedness and mitigation, and will promote technology transfer and institutional capacity building through direct involvement of professional associations, bankers, builders, insurance companies and reinsurers, NGOs, PVOs, community groups and government organizations in project activities.

For further information please contact:

Mr. Jan Vermeiren, Project Manager
Organization of American States
Unit of Sustainable Development and Environment
1889 F Street N.W.
Washington, D.C. 20006
Phone: (202) 458-3006
Fax: (202) 458-3560
E-mail: jvermeiren@oas.org

Ms. Jennifer Worrell Campbell, Regional Disaster Advisor
Office of Foreign Disaster Assistance
U.S. Agency for International Development
2 Haining Road
Kingston 5, Jamaica
Phone: (876) 926-4998
Fax: (876) 929-9944
E-mail: jworrell@usaid.gov

Natural Hazards in the Caribbean

Earthquakes

Earthquakes are caused by sudden release of slowly accumulated strain energy along a fault in the earth's crust. Earthquakes and volcanoes occur most commonly at the collision zone between tectonic plates. Earthquakes represent a particularly severe threat due to the irregular time intervals between events, lack of adequate forecasting, and the hazards associated with these:

- Ground shaking is a direct hazard to any structure located near the earthquake's center. Structural failure takes many human lives in densely populated areas.
- Faulting, or breaches of the surface material, occurs as the separation of bedrock along lines of weakness.
- Landslides occur because of ground shaking in areas having relatively steep topography and poor slope stability.
- Liquefaction of gently sloping unconsolidated material can be triggered by ground shaking. Flows and lateral spreads (liquefaction phenomena) are among the most destructive geologic hazards.
- Subsidence or surface depressions result from the settling of loose or unconsolidated sediment. Subsidence occurs in waterlogged soils,fill, alluvium, and other materials that are prone to settle.
- Tsunamis or seismic sea waves, usually generated by seismic activity under the ocean floor, cause flooding in coastal areas and can affect areas thousands of kilometers from the earthquake center.

Volcanoes

Volcanoes are perforations in the earth's crust through which molten rock and gases escape to the surface. Volcanic hazards stem from two classes of eruptions:

- Explosive eruptions which originate in the rapid dissolution and expansion of gas from the molten rock as it nears the earth's surface. Explosions pose a risk by scattering rock blocks, fragments, and lava at varying distances from the source.
- Effusive eruptions where material flow rather than explosions is the major hazard. Flows vary in nature (mud, ash, lava) and quantity and may originate from multiple sources.Flows are governed by gravity, surrounding topography, and material viscosity.

Hazards associated with volcanic eruptions include lava flows, falling ash and projectiles, mudflows, and toxic gases. Volcanic activity may also trigger other natural hazardous events including local tsunamis, deformation of the landscape, floods when lakes are breached or when streams and rivers are dammed, and tremor-provoked landslides.

Landslides

The term landslide includes slides, falls, and flows of unconsolidated materials. Landslides can be triggered by earthquakes, volcanic eruptions, soil saturated by heavy rains or groundwater rise, and river undercutting. Earthquake shaking of saturated soils creates particularly dangerous conditions. Although landslides are highly localized, they can be particularly hazardous due to their frequency of occurrence. Classes of landslide include:

- Rockfalls, which are characterized by free falling rocks from overlying cliffs. These often collect at the cliff base in the form of talus slopes which may pose an additional risk.
- Slides and avalanches, a displacement of overburden due to shear failure along a structural feature. If the displacement occurs in surface material without total deformation it is called a slump.
- Flows and lateral spreads, which occur in recent unconsolidated material associated with a shallow water table. Although associated with gentle topography, these liquefaction phenomena can travel significant distances from their origin.

The impact of these events depends on the specific nature of the landslide. Rockfalls are obvious dangers to life and property but, in general, they pose only a localized threat due to their limited areal influence. In contrast, slides, avalanches, flows, and lateral spreads, often having great areal extent, can result in massive loss of lives and property. Mudflows, associated with volcanic eruptions, can travel at great speed from their point of origin and are one of the most destructive volcanic hazards.

Flooding

Two types of flooding can be distinguished: (1) land-borne floods, or river flooding caused by excessive run-off brought on by heavy rains, and (2) sea-borne floods, or coastal flooding, caused by storm surges, often exacerbated by storm run-off from the upper watershed. Tsunamis are a special type of sea-borne flood.

Coastal flooding

Storm surges are an abnormal rise in sea water level associated with hurricanes and other storms at sea. Surges result from strong on-shore winds and/or intense low pressure cells and ocean storms. Water level is controlled by wind, atmospheric pressure, existing astronomical tide, waves and swell, local coastal topography and bathymetry, and the storm's proximity to the coast.

Most often, destruction by storm surge is attributable to:

- wave impact and the physical shock on objects associated with the passing of the wave front.

- Hydrostatic/dynamic forces and the effects of water lifting and carrying objects. The most significant damage often results from the direct impact of waves on fixed structures. Indirect impacts include flooding and undermining of major infrastructure such as highways and railroads.

Flooding of deltas and other low-lying coastal areas is exacerbated by the influence of tidal action, storm waves, and frequent channel shifts.

River flooding

Land-borne floods occur when the capacity of stream channels to conduct water is exceeded and water overflows banks. Floods are natural phenomena, and may be expected to occur at irregular intervals on all stream and rivers. Settlement of floodplain areas is a major cause of floodplain areas is a major cause of flood damage.

Tsunamis

Tsunamis are long-period waves generated by disturbances such as earthquakes, volcanic activity, and undersea landslides. The crests of these waves can exceed heights of 25 meters on reaching shallow water. The unique characteristics of tsunamis (wave lengths commonly exceeding 100 km, deep-ocean velocities of up to 700 km/hour, and small crest heights in deep water) make their detection and monitoring difficult. Characteristics of coastal flooding caused by tsunamis are the same as those of storm surges.

Hurricanes

Hurricanes are tropical depressions which develop into severe storms characterized by winds directed inward in a spiraling pattern toward the center. They are generated over warm ocean water at low latitudes and are particularly dangerous due to their destructive potential, large zone of influence, spontaneous generation, and erratic movement. Phenomena which are associated with hurricanes are:

- Winds exceeding 64 knots (74 mi/hr or 119 km/hr), the definition of hurricane force. Damage results from the wind's direct impact on fixed structures and from wind-borne objects.
- Heavy rainfall which commonly precedes and follows hurricanes for up to several days. The quantity of rainfall is dependent on the amount of moisture in the air, the speed of the hurricane's movement, and its size. On land, heavy rainfall can saturate soils and cause flooding because of excess runoff (land-borne flooding); it can cause landslides because of added weight and lubrication of surface material; and/or it can damage crops by weakening support for the roots.
- Storm surge (explained above), which, especially when combined with high tides, can easily flood low-lying areas that are not protected.

Annual Average Number of People Reported Killed or Affected by Disasters

by Country, 1970-1994

Country	**Killed**	**Affected**
Haiti	168	219,861
Dominican Republic	84	102,566
Puerto Rico	47	160
Guyana	36	10,859
Cuba	33	65,335
Jamaica	19	54,187
Suriname	7	N.A.
Bahamas	4	N.A.
Dominica	2	3,600
St. Lucia	2	2,944
Martinique	2	1,060
Anguilla	1	N.A.
Belize	1	3,731
Bermuda	1	N.A.
Trinidad & Tobago	0	2,000
Barbados	0	8
Antigua & Barbuda	0	3,000

Source: World Disasters Report 1996

Country	**Date**	**Hazards**	**Comment**
Anguilla	02/01/55 05/09/60	Hurricane Hurricane	Alice Donna
Antigua & Barbuda	01/09/50 04/09/60 26/09/66 08/10/74 11/83 16/03/85 17/09/89	Hurricane Hurricane Hurricane Earthquake Drought Earthquake Hurricane	Dog Donna Inez Major Extensive damage to agric sector 6.6 Richter Scale Hugo
Bahamas	26/07/26 26/09/29 29/09/35 14/09/45 18/10/63 09/65 03/10/66 08/92	Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane	Devastating Enormous damage In Bimini Heavy damage Flora Betsy Inez Andrew 4 killed
Barbados	22/09/55 10/70 03/08/80 10/83 25/10/84 10/09/31 28/09/55 31/09/61 09/74	Hurricane Floods Hurricane Flood Floods Hurricane Hurricane Hurricanes Hurricane	Janet Entire Island Allen Speightstown Widespread 1,500 killed Janet Hattie Carmen & Fifi
Belize	09/78 12/79 17/05/82	Floods Fire	Greta - 5 deaths, 6,000 affected Torr, rains Belize City
Bermuda	12/10/48 01/86 25/09/87	Hurricane Tornadoes Hurricane	Heavy damage 5 parishes Emily
British Virgin Islands	1932 23/05/69 07/09/70 04/83 11/84	Hurricane Flood Flood Flood & rains Tropical Storm	Tortola damaged 19" rain recorded Heavy damage Heavy damage

Major Disasters in the Caribbean: 1899—1989

Country	Date	Hazards	Comment
Cuba	20/10/26	Hurricane	600 killed
	09/11/32	Hurricane	2,500 killed
	28/09/35	Storm Surge	Many fatalities
	18/10/44	Storm	--
	21/09/48	Hurricane	Heavy Damage
	05/10/48	Hurricane	--
	04/10/63	Hurricane	Alma
	06/06/66	Hurricane	Flora
	30/09/66	Hurricane	Inez
	13/10/68	Hurricane	Gladys
	19/02/76	Earthquake	--
	06/77	Floods	Eastern area
	11/02/78	Storm	Gale
	03/06/82	Hurricane	Alberto
	Feb/Mar/83	Rains/floods	10 weeks of Torrential rains
	25/05/85	Heavy rains	+ tornadoes
	18/11/85	Hurricane	Kate
	06/86	Floods	+ landslides
	08/87	Fire	--
	26/05/88	Flood	20 killed, 90,000 affected
	28/05/90	Flood	6,000 affected
	06/02/92	Flood	9,127 affected
	25/05/92	Earthquake	7 Richter Scale,000 affected
Dominica	04/03/03	Earthquake	--
	16/02/08	Earthquake	Slight damage
	04/02/35	Earthquake	--
	21/05/46	Earthquake	7.0 Richter scale
	25/09/63	Hurricane	Edith
	08/79	Hurricanes	David & Frederick
	09/10/84	Hurricane	--
	09/03/86	Earthquake	--
	9/89	Hurricane	Hugo
Dominican Republic	03/09/30	Hurricane	2,000 killed
	02/10/63	Hurricane	Flora
	08/64	Hurricane	Cleo
	04/65	Forest Fire	--
	29/09/66	Hurricane	Inez
	1968	Drought	Nationwide
	27/04/79	Floods	N/N-E areas
	08/79	Hurricanes	David & Frederick
	May 81	Floods	Heavy rains
	12/02/83	Forest fire	--
	29/05/86	--	--
	02/09/87	Hurricane	Emily
	08/88	Flood	1,191,150 affected

Country	Date	Hazards	Comment
Grenada	1955 03/09/63 27/04/90	Hurricane Hurricane Fire	Janet Flora --
Guadeloupe	12/09/28 11/08/56 06/10/63 22/08/64 27/09/66 20/08/70 30/08/76 16/03/85	Hurricane Hurricane Tropical Storm Hurricane Hurricane Tropical Storm Volcano Eruption Earthquake	Betsy Helena Cleo Inez Dorothy Mt. Soufriere 6.6 Richter scale
Guyana	07/71 18/11/78	Floods Accident	21,000 affected 900 killed, Jonestown Massacre
Haiti	12/11/09 12/08/15 21/10/35 27/10/52 12/10/54 03/10/63 14/11/63 24/08/64 29/09/64 1968 07/08/72 1974-75 1977 31/08/79 11/05/80 05/08/80 1980-81 20/05/85 16/05/86 01/06/86 03/06/86 Apr-Oct 86 23/10/86 10/07/87 12/87 11/09/88	Hurricane Hurricane Hurricanes Earthquake Hurricane Hurricane Floods Hurricane Hurricane Drought Fire Drought Drought Hurricane Fire Hurricane Drought Floods Fire Floods Floods Fire/floods Floods Heavy rains Flood Hurricane	150 killed 1,600 killed Jeremie & Jacme 6 killed Hazel Flora 500 killed Cleo Inez 210,000 affected Port-au-Prince N/W Peninsula countrywide David 10,000 affected Allen S/W area 40,000 affected 3,300 homeless Extensive Damage Heavy rains + Emergency 100 homeless Extensive damage 3,000 affected Gilbert: 54 dead, 870000 affected

Major Disasters in the Caribbean: 1899—1989

Country	Date	Hazards	Comment
Jamaica	10/08/03	Hurricane	Heavy damage
	14/01/07	Earthquake	1,200 killed
	04/11/09	Flood	53 killed
	12/11/12	Hurricane	Heavy damage
	23/11/37	Flood	111 killed
	18/11/40	Flood	125 killed
	20/08/44	Hurricane	26 dead
	17/08/51	Hurricane	Charlie
	03/10/63	Hurricane	Flora
	1968	Drought	Nationwide
	17/10/73	Tropical storm	Gilda
	25/04/79	Floods	Western area
	06/79	Floods	Widespread
	05/08/80	Hurricane	Allen
	11/11/85	Hurricane	Kate
	15/05/86	Floods	Islandwide
	30/10/87	Floods	Tropical Storm
	12/09/88	Hurricane	Gilbert (49 killed, 810,000 affected)
	21/05/91	Flood	550,000 affected
Martinique	08/05/02	Volcano eruption	Mt. Pelee 40,000 killed
	08/08/03	Hurricane	Heavy damage
	16/02/06	Earthquake	--
	17/04/14	Earthquake	--
	26/09/9	Earthquake	--
	02/09/51	Hurricane	Crops destroyed
	19/03/53	Earthquake	Building damage
	10/07/60	Hurricane	Abby
	25/09/63	Hurricane	Edith
	07/09/67	Hurricane	Buelah
	20/08/70	Tropical storm	Dorothy
	08/79	Hurricane	David
	04/10/90	Hurricane	Klaus 6 killed, 1,500 affected
Montserrat	28/08/24	Hurricane	Heavy damage
	12/09/28	Hurricane	Heavy damage
Martinique	12/12/34	Earthquake	Building damage
	10/11/35	Earthquake	Building damage
	16/03/85	Earthquake	6.6 Richter scale
	17/09/89	Hurricane	Hugo
Netherland Antilles	Aug 1899	Hurricane	Heavy damage
	01/09/50	Hurricane	Dog
	04/09/80	Hurricane	Donna

Country	Date	Hazards	Comment
Puerto Rico	Aug 1899 06/09/10 11/10/18 24/10/18 23/07/26 13/09/28 10/09.31 08/32 12/08/56 08/60 1989	Hurricane Hurricane Earthquake Earthquake Earthquake Earthquake Earthquake Earthquake Earthquake Hurricane Hurricane	6,000 killed San Juan damaged Extensive damage Deaths/damages Deaths/damages Deaths/damages Deaths/damages Deaths/damages Deaths/damages Donna Hugo
St. Kitts (Saint Christopher) and Nevis	13/09/28 12/50 02/10/55 1984 16/03/85 05/87 17/09/89	Hurricane Earthquake Hurricane Floods Earthquake Flood Hurricane	Heavy damage Heavy damage Alice In Basseterre 6.6 Richter scale -- Hugo
St. Martaen/Saba	30/12/54 04/09/60	Hurricane Hurricane	Alice Donna
St. Lucia	16/02/06 21/05/46 19/03/53 10/07/60 25/09/63 07/09/67 03/08/80 08/83 08/09/86	Earthquake Earthquake Earthquake Hurricane Hurricane Tropical Storm Hurricane Storm Tropical Storm	Extensive damage Building damage Building damage Abby Edith Beulah Allen Gale force winds Danielle
Saint Vincent and the Grenadines	08/05/02 17/07/02 17/09/06 26/09/28 21/05/46 19/03/53 23/09/55 08/09/67 17/10/71 13/04/79 03/08/80 08/09/86 21/09/87	Volcanic Eruption Earthquake Earthquake Earthquake Earthquake Earthquake Hurricane Tropical Storm Volcanic Eruption Volcanic Eruption Hurricane Trop Storm/Flood Hurricane	Mt. Soufriere (1,565 killed) Buildings damaged -- -- -- Buildings damaged Janet Beulah Mt. Soufriere Mt. Soufriere Allen Darrielle Heavy damage Emily
Surriname	01/08/69	Floods	4,600 affected

Major Disasters in the Caribbean: 1899—1989

Country	Date	Hazards	Comment
Trinidad & Tobago	31/01/04 26/03/15 24/02/18 04/12/54 27/06/33 30/09/63 14/08/74	Earthquake Earthquake Earthquake Earthquake Hurricane Hurricane Tropical Storm	Building damage Building damage Building damage Building damage Heavy damage Flora Alma
Turks and Caicos Islands	20/11/85 21/09/87	Hurricane Hurricane	Kate Emily
US Virgin Islands	Aug 1899 Aug 1899 01/10/01 22/08/09 14/07/16 21/08/16 09/10/16 28/08/24 12/09/28 10/09/31 26/09/32 07/05/60 01/03/69 05/70 10/70 1989	Hurricane Hurricane Hurricane Tropical Storm Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane Hurricane Flood Flood Flood Flood Hurricane	Heavy damage and major flood surge Heavy damage to St. Thomas Damage to St. Croix Major flooding Damage to St. Croix Heavy damage Heavy damage Heavy damage Heavy damage Heavy damage Heavy damage Heavy damage to St. Thomas Heavy damage Heavy damage Extensive damage to St. Thomas Hugo

Source: Disaster Information Kit for the Media (ver 05/95) Data based on records available from:

1. OFDA Disaster History: "Significant Data On Major Disasters Worldwide, 1900 - present of June 87"
2. PCDPPP'S "Caribbean Disaster News," issues Nod. 1-11 (1984-present)
3. PCDPPP Documentation Centre, 1988
4. UNDRO's computerized list of situation/information reports ("Sitrep.Prints")
5. World Map of Natural Hazards, Muenchener Rueckversicherungs Gesellschaft, 1978

REFERENCES

From Coch, Nicholas K. 1995. *Geohazards: Natural and Human.* Englewood Cliffs, NJ: Prentice Hall.

General

American Institute of Professional Geologists. 1993. *The Citizens Guide to Geologic Hazards.* 134p.

Bolt, B.A., W.L. Horn, G.A. MacDonald, and R.F. Scott., 1977. *Geologic Hazards*, rev. 2nd ed. New York: Springer-Verlag. 330p.

Coch, N.K, and A. Ludman. 1991. *Physical Geology*. New York: Macmillan. 678p.

U.S. Geological Survey. 1981. "Facing Geologic and Hydrologic Hazards," Professional Paper 1240-B. 108p.

Plate Tectonics

Hamblin, W.K. 1992. "Chapter 18: Plate Tectonics," in *Earth's Dynamics Systems*, 6th ed. New York: Macmillan. 647p.

Erosion

Birkeland, P.W. 1984. *Soils and Geomorphology.* New York: Oxford University Press. 285p.

Coch, N.K. and A. Ludman. 1991. *Physical Geology*. New York: Macmillan. 678p.

Wind

Christopherson, R.W. 1994. "Chapter 8: Weather," p. 228-239 in *Geosystems: An Introduction to Physical Geography*, 2nd ed. New York: Macmillan.

Volcanoes

Coch, N.K. and A. Ludman. 1991. "Chapter 5: Volcanoes," in *Physical Geology*. New York: Macmillan. 678 p.

Bolt, B.A., W.L. Horn, G.A. MacDonald, and R.F. Scott. 1977. "Chapter 3: Hazards from Volcanoes," In *Geologic Hazards*, rev. 2nd ed. New York: Springer-Verlag. 330p.

McPhee, J. 1989. "Chapter 2: Cooling the Lava, in *The Control of Nature.* New York: Farrar Strauss Giroux. 272p.

Parks, N. 1994. Exploring Loihi: The Hawaiian Island *Earth* 3(5-Sept.):56-63.

Parks, N. 1994. The Fragile Volcano *Earth* 3(6-Nov.):42-49.

Pendick, D. 1994. Under the Volcano Earth 3(3-May):34-39.

Tilling, R.I. 1989. Volcanic Hazards and Their Mitigation: Progress and Problems *Reviews of*

Geophysics 27:237-269.

Wright, T.L. and T.C. Pierson. 1992. "Living with Volcanoes," U.S. Geological Survey Circular 1073. 57p.

Earthquakes

Bolt, B.A., W.L. Horn, G.A. MacDonald, and R.F. Scott. 1997. "Chapter 1: Hazards from Earthquakes," in *Geologic Hazards*, rev. 2nd ed. New York: Springer-Verlag. 330p.

Coch, N.K. and A. Ludman. 1991. "Chapter 19: Earthquakes and Seismology," in *Physical Geology*. New York: Macmillan. 678p.

Davidson, K. 1994. Learning from Los Angeles *Earth* 3(5-Sept.):40-48.

Davidson, K. 1994. Predicting Earthquakes *Earth* 3(3-May):56-63.

Nicholas, D.R. and J.M. Buchanan-Banks. 1974. "Seismic Hazards and Land Use Planning," U.S. Geological Survey Circular 690. 33p.

Petroski, H. 1994. Broken Bridges *American Scientist* 82(4 July-Aug.)318-321.

Tsunamis

Bolt, B.A., W.L. Horn, G.A. MacDonald, and R.F. Scott. 1997. "Chapter 3: Hazards from Tsunamis," in *Geologic Hazards*, rev. 2nd ed. New York: Springer-Verlag. 330p.

Flooding

Chen, A. 1983. Damned If They Do and Damned If They Don't *Science* 123(March 26):204-206.

Tennessee Valley Authority. 1983. Floodplain Management 80p.

U.S. Army Corps of Engineers. 1983. "Streambank Protection Guidelines for Landowners and Local Governments," Vicksburg, MI: U.S. ACE, Waterways Experimental Station. 60p.

U.S. Army Corps of Engineers. 1992. "Floodproofing Regulations," Washington, DC: U.S. Government Printing Office, 1992-621-474/41697.

Landslides

Coates, D.R., ed. 1977. *Landslides: Geological Society of America Reviews in Engineering Geology*, vol. 3, 278p.

Fleming, R. W. and Taylor, F.A., 1980. ":Estimating the Cost of Landslide Damage in the United States," U.S. Geological Survey Circular 832.

Jones, D.E., Jr. and W.G. Holtz. 1973. Expansive Soils: The Hidden Disaster *Civil Engineering* Augst: 49-51.

Radbrunch-Hall, D., et al., "Landslide Overview Map of the Coterminous United States," U.S. Geological Survey, Professional Paper 1183, 25p.

U.S. Geological Survey. 1987. "Chapter 4: Hazards from Ground Failures," in W.W. Hays, ed., "Facing Geologic and Hydrologic Hazards," U.S. Geological Survey Circular 1008, 43p.

Subsidence

American Institute of Professional Geologists (AIPG). 1993. *The Citizens' Guide to Geologic Hazards, Landslides, and Advalanches*. Arvada, CO: AIPG. 134p.

American Institute of Professional Geologiosts (AIPG). 1993. *The Citizens' Guide to Geologic Hazards: Subsidence*. Arvada, CO: AIPG. 79p.

Beck, B.F. 1988. Environmental and Engineering Effects of Sinkholes: The Processes Behind the Problem *Environmental Geology and Water Science* 12(2): 71-78.

Dolan, R. and Goodell, H.G. 1986. Sinking Cities *American Scientist* 74:38-47.

Holzer, T.L., ed. 1984. *Man Induced Land Subsidence: Geological Society of America Reviews in Enginering Geology*, v. VI, 232 p.

Marsden, S.S. and S.N. Davis. 1967. Geological Subsidence *Scientific American* 216(6):93-108.

Greenhouse Effect

Barnett, R. 1986. Ozone Protection: The Need for a Global Solution *EPA Journal* 12(10-Dec.):10-11.

Mintzis. M.M. 1986 Skin Cancer: The Price of the Ozone Layer *EPA Journal* 12(10-Dec): 7-9.

Rind, D. 1986. The Greenhouse Effect: An Explanation *EPA Journal* 12(10-Dec.):12-14.

Rodhe, H. 1990. A Comparison of the Contribution of Various Gases to the Greenhouse Effect *Science* 248(6):1217-1219.

Rowland, F.S. 1986. A Threat to Earth's Protective Shield*EPA Journal* 12(10-Dec.):4-6.

Rowland, F.S. 1989 Chloroflourocarbons and the Depletion of Stratospheric Ozone *American Scientist* 77(Jan.-Feb.):36-45.

Reef and Mangroves as Storm Absorbers

Flanagan, R. 1993 Corals under Siege *Earth* 2(3-May):26-35.

Niegel, J.E. and J.C. Aviso. 1984. On a Coral Reef, It's a Hard Knock Life*Natural History* 93(12):58-64.

Snedaker, J. 1987. Mangrove Mythology *Florida Naturalist* Fall:7-8.

Coastal Processes

Davis, R.A., Jr., ed. 1978. *Coastal Sedimentary Environments*. New York: Springer-Verlag.

420p.

Federal Emergency Management Agency. 1986. "Coastal Construction Manual," 104p.

Fox, W.T. 1976. "Weather Patterns and Coastal Processes," in R.A. Davis, Jr. and R.L. Ethington, eds. "Beach and Nearshore Sedimentation," Tulsa, S.E.P.M., Spec. Publication No. 24, p 1-23.

Kaufman, W. and Pikey, O.H. 1979. *The Beaches Are Moving: The Drowning of America's Shoreline.* Garden City, NY: Anchor/Doubleday. 326 p.

Leatherman, S.P. 1988. *Barrier Island Handbook.* College Park, MD: University of Maryland Laboratory for Coastal Research. 931 p.

South Carolina Coastal Council. 1990. *Understanding Our Coastal Environment.* Charleston, SC. 40p.

Sea Level Rise

Federal Emergency Management Administaration. 1991. "Projected Impact of Relative Sea-Level Rise on the National Flood Insurance Program," 72.p.

Titus, J.G. 1986. Rising Sea Levels: The Impact They Pose *EPA Journal* 12(10-Dec.):17-20.

Hurricanes

Christopherson, R.W. 1994. "Chapter 8: Weather," in *Geosystems: An Introduction of Physical Geography*, 2nd ed. New York: Macmillan.'

Fund, B. 1980. Hurricane *National Geographic* September: 346-379.

Gore, R. 1993. Andrew Aftermath *National Geographic* April: 2-37.

Simpson, R.H. and Riehl, H. 1981. *The Hurricane and Its Impact.* Baton Rouge, LA: Louisiana State University Press.

Hazard Mitigation Planning:
Tools and Techniques

I. Structural Measures

A. Alteration of environment

B. Strengthening Buildings and Facilities

II. Non-structural Measures

A. Development Management

B. Information Dissemination

III. Private Sector

I. Structural Measures

A. Alteration of environment

1. Sediment-trapping Structures

a. Groins: Groins are wall-like structures, built of timber, concrete, metal sheet piling or rock, placed perpendicular to the beach to capture material drifting along the shoreline. A groin' s effectiveness in trapping sediment is primarily a factor of the length and the spacing of the groin system. The appropriate length for an effective groin depends on the dominate sediment size: shorter groins for larger grain sizes and longer groin for smaller grain size. The spacing between groins must balance being large enough to not undermine the updrift groin and being small enough to effective act as a sediment trap.

b. Jetties: Jetties are wall-like structures built perpendicular to the coast to stabilize channels, inlets and outlets. While the primary function of jetties is to protect navigation channels, jetties capture sediments by restricting the movement of materials transported by longshore currents. The critical factors for channel stabilization are the width of the channel and management of sediment. Width of the channel must balance being wide enough to reduce current velocity within the channel but narrow enough to restrict shoaling. Likewise, consideration of the sediment economy plays a vital role in the long-term viability of the channel, inlet or outlet.

2. Sediment-moving Structures

a. Beach nourishment: Beach nourishment is the artificial replacement and/or addition of sediment to beaches. The effectiveness of beach nourishment depends on the type of imported sand, natural slope of the beach, cross shore currents, and the frequency of storms. Consideration of natural erosional process is vital to the long-term cost-effectiveness of any beach nourishment program.

b. Dredging: Dredging involves modification of a channel by extracting sediment. Due to the need to dispose of extracted sediment and likelihood of future sedimentation, dredging is usually only undertaken to maintain the navigability of channels and waterways.

3. Shoreline Protection Works

a. Seawalls: Seawalls are vertical walls built on the shoreline that are designed to protect against direct storm wave attack. Seawalls must be constructed of durable, immovable materials to withstand the extreme, dynamic power of storm waves. Due to the size needed to be effective, seawalls can also be curve or stepped to dissipate smaller waves and reflect larger storm waves.

b. Revetments: Revetments are designed to protect the backshore from high tides and surges. Revetments may be constructed out of a number of materials and configurations, from boulders placed at the edge of a cliff or along the backshore, to securing loose material in wire gabions, to pre-cast armor units. Revetments are more successful on lower energy coasts.

c. Bulkheads: Bulkheads are vertical walls on the shoreline, often constructed of wood or steel, and designed to retain loose fill and sediment behind it. Since the purpose of bulkheads is to maintain the material behind it rather than provide protection from the sea or lake, bulkheads are usually not good protection from storms or other flooding events.

d. Breakwaters: Unlike seawalls, revetments, and bulkheads, breakwaters protect the shoreline by breaking down incoming waves to diffuse and refract the wave fronts. Breakwaters must be strong to be effective because they receive the full force of the wave energy. Consideration of materials is especially important for breakwaters due to the environmental forces acting on them.

e. Construction and stabilization of sand dunes: Construction of new sand dunes requires an understanding of the biological and physical processes of the coastal zone. Most effective methods of creating new dunes involves disrupting the airflow to encourage sand deposition, through the use of fences made of porous materials. It is important that the fences alter the air flow but do not halt it. Artificial dunes can also be built up by the planting of vegetation. It is important to note the distinction between vegetation used for dune construction and for dune stabilization, as they are usually of different species. Stabilization, as opposed to construction, of dunes is aimed at securing bare sand surfaces against deflation. Stabilization can be achieved through grading, rapid construction of new dunes through the use of earth-moving equipment, surface fixing by addition of chemicals, and planting of vegetation, focusing on grasses, shrubs, and trees.

4. Flood Control Works

a. Dams and reservoirs: A dam is a structure built across a waterway to impound water. Dams, as well as acting as flood control devises, also serve for maintaining water depths for navigation, irrigation, water supply, hydropower and others. Dams can serve as effective flood control measures by retaining water and releasing it at a controlled rate that does not overwhelm the capacity of the channel beyond. Any dam or reservoir should include a spillway—a feature of a dam allowing excess water to pass without overtopping the dam. Usually a spillway functions only in a large flood. Storage capacity of a dam or reservoir should be a primary consideration in design and construction. In addition, the normal sediment load on the waterway to be dammed plays an important role in the long-term viability of the dam. Sedimentation can silt-up a reservoir and increase its volume, decreasing its flood storage capacity.

b. Dikes and levees: Dikes and levees are often used synonymously. Dikes are usually an earthen or rock structure built partially across a river for the purpose of maintaining the depth and location of a navigation channel. Levees are earthen embankments used to protect low-lying lands from flooding. Levees are built between the floodway and the structures to which they are intended to protect. The effectiveness of a levee to reduce the threat of flood damage on structures and low-lying areas depends on the levee being located outside of the floodway and compensating for the flood storage displaced by it. Locating a levee (or any other structure) within the floodplain can increase the flood height, increasing flood threat both up and downstream.

c. Retaining ponds: Retaining ponds or retention ponds are basins designed to catch surface runoff to prevent its flow directly into a stream or river. Retention ponds are frequently a relatively inexpensive option, provided that ample undeveloped land is available. Retaining ponds have the added advantage of not altering the character of the stream. Retaining ponds can also act as groundwater recharging sites and reduce water pollution through soil filtering.

d. Flood channels: Channelization is a general term for various modifications of the stream channel that are usually intended to increase the velocity of the water flow, the volume of the water channel, or both. These modifications, in turn, increase the discharge of the stream, and the rate at which surplus water is carried away. The channel can be widened or deepened, especially where soil erosion and subsequent deposition in the stream have partially filled in the channel. Care must be taken, however, that channelization does not alter the stream dynamics too greatly elsewhere. Flood channels or storm sewers are installed to keep water from flooding streets during heavy rains, and, often, the storm water is channeled straight into a nearby stream. This can become a problem by increasing the probability of flooding downstream through greater water volume in streams than would occur naturally. This is particularly a problem when the flood channel is cement lined, thereby further increasing the rate at which water enters streams.

e. Floodwall: A floodwall is a reinforced concrete wall that acts as a barrier against floodwaters. Floodwalls are usually built in lieu of levees where the space between land and the floodplain is limited.

5. Stormwater Management: Beyond maintenance and improvement of urban storm water systems, land treatment measures are effective means of counter-acting the effects of urbanization (particularly the increase in impervious surfaces) on runoff. Land treatment measures include maintenance of trees, shrubbery, and vegetative cover; terracing; slope stabilization; grass waterways; contour plowing; and strip farming. The use of perennial vegetation, such as grasses, shrubs and trees provide cover for the soil, prevent erosion, slow the rate of runoff and increase infiltration, and reduce water pollution. Terracing involves a raised bank of earth having vertical or sloping sides and a flat top for controlling surface runoff. Strip cropping is the growing of crops in a systematic arrangement of strips or bands along a contour.

6. Drainage system maintenance: Maintenance of channels and detention basins is necessarily an ongoing venture due to blockages caused by overgrowth, debris, sedimentation, and aging of systems. Replacement and/or improvement of culverts, mains, stormwater lines, sewer pipes, backup valves, etc., may be part of a general program of maintenance and improvement to reduce flooding hazards.

7. Slope stabilization: A number of potential methods are available to stabilize slopes from landslides, including slope reduction, adding retention structures, fluid removal, and others. Slope reduction involves reducing the slope angle, placing additional support material at the foot of the slope to prevent a slide or flow at the base of the slope, and/or reducing the load on the slope by removing some of the materials high on the slope. Retention structures may include ground cover and retaining walls. The most successful retaining walls tend to be low, thick walls placed at the toe of a slide. Fluid removal acts to reduce the role water can play in landslide by covering the surface with impermeable material and diverting runoff away from the slope, as well as installing a subsurface drainage system. Other methods include cementing the slide material, bolting a rock slide, and the driving of vertical piles into the foot of the slope.

8. Brush clearing, controlled burns, fuels breaks: Brush clearing, controlled burns, and creating fuels breaks are all ways of mitigating the threat from wildfires by reducing the material that can be burned and the area in which it can spread.

9. Wetland preservation: Wetlands are areas that are normally inundated with water. Many important ecological communities are found in wetlands, including bottomland hardwoods, swamps, marshes, bogs, sloughs, potholes, wet meadows, river overflow, mud flats, and natural ponds, and are essential for a number of species of fish and wildlife. Wetlands act as flood control by storing tremendous amounts of floodwaters, slowing and reducing downstream flows. Wetlands also play an important role in coastal productivity and the cycling of river-borne material (pollutants included) by acting as a biogeochemical filter.

B. Strengthening Buildings and Facilities

1. Strengthening Buildings

a. Floodproofing: Floodproofing can be done in two ways: dry and wet. Dry floodproofing involves the sealing of a building against floodwaters by making all areas below the flood protection level watertight. This can be done by coating walls with waterproofing compounds or plastic sheeting and protecting building openings with removable shields or sandbags. Dry floodproofing is limited to 2 or 3 feet above the foundation of the building due to the pressure exerted by deeper water on the walls and floors. With wet floodproofing, floodwaters are intentionally allowed to enter a building to reduce the pressure exerted by deep water. Wet floodproofing at minimum involves the removal of some valuable items and extends to the rebuilding of floodable areas. Wet floodproofing can dramatically reduce damage costs by simply removing furniture and electrical appliances out of the floodprone area.

b. Elevating: Elevating a building is the raising of that building above the flood level. This is the one of the best techniques for protecting buildings that are, or for some reason must be, located in areas prone to flooding. Elevation is cheaper than relocation and is less disruptive to the neighborhood. Effective elevation should take in consideration the need to wet floodproof everything still located in the floodprone area, such as basements or garages.

c. Windproofing: Windproofing focuses on design and construction of a building to withstand wind damage. This involves the aerodynamics of a structure, materials used, and addition of features such as storm shutters.

d. Basement protection: Basement protection may involve floodproofing of the structure, both wet and dry, as well as building a barrier around the opening to the basement to protect it from floodwaters.

e. Seismic retrofitting: Seismic retrofitting involves adding braces, removing overhangs, and providing flexible utility connections and tie downs to reduce damage.

2. Strengthening Facilities

a. Floodproofing: Floodproofing can be done in two ways: dry and wet. Dry floodproofing involves the sealing of a facility against floodwaters by making all areas below the flood protection level watertight. This can be done by coating walls with waterproofing compounds or plastic sheeting and protecting facility openings with removable shields or sandbags. Dry floodproofing is limited to 2 or 3 feet above the foundation of the facility due to the pressure exerted by deeper water on the walls and floors. With wet floodproofing, floodwaters are intentionally allowed to enter a facility to reduce the pressure exerted by deep water. Wet floodproofing at minimum involves the removal of some valuable items and extends to the rebuilding of floodable areas.

b. Burial: Burial can play an important role in protecting necessarily utility connections, particularly during high winds and ice storms.

c. Elevating: Elevation of facilities is the raising of the facility above the flood level. Of particular importance for facilities is the elevation of electrical and mechanical equipment. It may not be possible to effectively raise many facilities, but by elevating electrical and mechanical equipment, the facility should be able to recover quicker after a disaster.

d. Seismic retrofitting: Seismic retrofitting involves adding braces, removing overhangs, and providing flexible utility connections and tie downs to reduce damage.

e. Improvements to stormwater/wastewater/water treatment facilities, pump stations: Improvements to stormwater, wastewater, water treatment facilities, and pump stations should be undertaken to minimize threat from flooding and other disasters. Capacity of these systems should be evaluated and, if necessary, increased to meet realistic demands.

f. Upgrading piers/wharves: Wharves and piers should be upgraded and retrofitted to match the storm forces they are exposed to.

g. Repair/reconstruction of fuel storage tanks: Fuel storage tanks need to be inspected and if necessary, repaired or reconstructed in the event of flooding or earthquake.

h. Storm shutters: Storm shutters are an important defense against high winds. Storm shutters protect a facility by preventing winds from entering a building and possibly damaging it.

3. Building Codes: Building codes are laws, ordinances, or governmental regulations setting forth standards and requirements for the construction, maintenance, operation, occupancy, use or appearance of buildings, premises, and dwelling units. Building codes should be designed to ensure that development is built to withstand natural hazards. Regulatory standards should created for the following:

a. Freeboard
b. Foundation Design
c. Wind Standards
d. Cumulative Substantial Improvement
e. Lower Substantial Improvement
f. Critical Facilities
g. Enclosure Limits
h. Electrical and Mechanical Equipment

II. Nonstructural Elements

A. Development Management

1. Planning

a. General comprehensive planning: Comprehensive plans and land use plans identify how a community should be developed and where development should not occur. Uses of the land can be tailored to match the land’ s hazards, typically by reserving hazard areas for parks, golf courses, backyards, wildlife refuges, natural areas, or similar compatible uses. Generally, a plan has limited authority. It reflects what the community would like to see happen. Its utility is that it guides other local measures, such as capital improvement programs, zoning ordinances, and subdivision ordinances.

b. Storm hazard mitigation and post-storm reconstruction plans: A locality should develop a set of policies or planning instruments to have in place to facilitate post-storm decision making. This allows for substantial amount of decision-making to occur prior to the disaster event and permits better decision-making after the event. Storm hazard mitigation and post-storm reconstruction plans should identify priorities both for reconstruction and mitigation.

2. Development Regulations

a. Zoning: Zoning is the division of a jurisdiction into districts and the prescription of uses for which buildings within designated districts may be put—their lot size, yard size, etc.

i) Overlay zones: These zones coexist with other zones, operating like a transparency overlaying existing land use controls. Examples include floodplain and historic districts; within these areas development is regulated by the standard zoning ordinance and the unique requirements of the overlay zone.

Overlay zones allow communities to isolate and protect areas not covered by the rest of the ordinance. However, like any zoning, the protections of overlay zones can be changed or removed.

ii) Agricultural zones: This zoning category sets a minimum lot acreage calibrated to the size necessary to maintain a commercial farm (which varies depending on the predominant crops grown in the region). Some ordinances contain a prohibition on non-farm uses (exclusive use).

An unintended consequence of the diminution of property value is that farmers are deprived of the collateral necessary for financing, making farming unfeasible. Non-exclusive use leads to renting, which does not induce major improvements in the land. A lack of such improvements reduces the viability of farming in the larger area, which in turn creates pressure to allow development. Finally, as with any zoning, this category must allow some reasonable economic use.

iii) Contract or conditional zoning: Under both approaches the landowner agrees to previously unstated conditions (which can be in the form of deed restrictions) in exchange for some government action (such as a rezoning) or an exemption from other conditions. The difference between the two is that with contract zoning the government is contractually obligated to allow the use.

The purpose of these techniques is to provide flexibility in dealing with a small number of land parcels, but they can nevertheless be unpopular with developers. Contract zoning is vulnerable to an *ultra vires* challenge (the government has impermissible delegated its authority), and both can be challenged under uniformity provision (that all land in zoning district be subject to the same restrictions), as spot zoning, or as contradicting a comprehensive plan.

iv) Special exception: This term, which is often used interchangeably with conditional use, is used for activities which are permissible but require an additional layer of approval because they need additional attention or cannot be reasonably accommodated in a traditional zoning ordinance. In some cases the use can be by right if the developer meets certain conditions.

While designating most uses as special exception may be illegal, the application of the technique against all new development has been upheld when used in connection with interim zoning or if the jurisdiction already had an adequate facilities requirement.

v) Bonus and incentive zoning: In exchange for concessions from a developer, some governments allow developers to exceed limitations imposed by current regulations, such as building height or dwelling unit density.

This technique has not seen much use outside of non-metropolitan areas. While similar to the accepted practice of dedication, bonuses and incentives may be vulnerable as contract zoning, and the extent of the connection needed between the concession and the government purpose is not clear.

vi) Floating zones: These zones appear in the text of zoning ordinance, but not on the map, and are typically used for shopping centers, industrial areas, mobile home parks, or multi-family housing.

While the location of floating zones can be subject to special interests and politics, they are usually based on facts, as opposed to speculated future needs. They may be vulnerable to a challenge of giving too much discretionary power or as spot zoning.

vii) Density transfers/ average density/ cluster: This type of regulation allows flexible design of large or small scale developments that are constructed as a unit; the actual design is matter of negotiation, but the basic premise is that some areas are developed more intensively than would normally be allowed, while others are used less than what the market would determine. The type of development usually has to conform to zoning, but there is a trend toward allowing mixed use.

The government’ s goal for this designation is to create open space, protect sensitive features and/or allow farming to continue, while the developer benefits for the higher dwelling unit density or floor area ratios. One consequence can be a form of leapfrog development, with its more expensive public services. Some farm-related uses may be incompatible with residential development, and development can lower farming activity below a critical mass.

viii) Performance or impact zoning: Rather than enumerating permitted uses, performance zoning sets standards for the effects or level of impact allowed for development. The standards may govern traffic, runoff, or viewsheds. The ordinance could theoretically allow any use as long as it met the requirements, but in practice most performance controls are used in conjunction with traditional zoning.

The level of expertise and size of the staff required to implement the standards depends on their comprehensiveness and how much of the jurisdiction they encompass. Performance zoning gives developers greater flexibility, but in some cases it may make enforcement more difficult. In addition, some impacts are difficult or impossible to quantify.

ix) Urban growth boundary: Urban containment basically involves designating a perimeter around an urban area. Urban development is encouraged within the line and discouraged beyond it, generally by restricting land to resource use and very low density residential development and precluding the extension of urban services. The area within the perimeter is designed to be sufficient to accommodate the area' s growth for a specified period.

The objective of urban containment is to promote compact and contiguous development, to preserve resource production lands, open space, and sensitive areas, and create a clear boundary between urban and rural areas. If the area is too large, the boundary may not achieve its goal of compact development; if it' s too small, property values may increase dramatically.

x) Specific development plans; shadow platting: This technique creates a plan which describes land uses and subdivisions in greater detail and covers a smaller area than a comprehensive plan, zoning map, or public facilities plan. The plan may include designation of specific uses and/or design standards that vary from the zoning ordinance and may even contain enough detail to allow approval of developments which comply without public hearing.

The objective of these plans is to preclude inefficient land use in areas designated for future growth at urban densities. The plans can also create neighborhood identity, coordinate development of different properties, and establish a fast track for development approvals.

xi) Total population limits; development caps: As the name implies, these are absolute limits on housing units or population itself. If a limit succeeds in limiting growth but demand for housing is high, property values will necessarily increase, which can affect the character of the community. The limits themselves do not address quality, type and location of growth, and restricting only one development sector can lead to an imbalance of growth. Not surprisingly, a restriction on growth can cause development to leapfrog out to neighboring jurisdictions.

xii) Rate allocation systems; growth phasing: Allocation systems and growth phases specify a rate of growth, which can be a percentage of total growth or a set number of units or square footage allowed per year.

These techniques are versatile, as they can be used to address quality, type and location of growth. In some cases developers compete for points which allow them to build. The points are based on criteria deemed desirable by the community, such as open space preservation, but the competition itself can be complex and time consuming to administer. If the rate or phases are slower than the market, property values will necessarily increase, which can affect the character of the community. A slower than market rate can also cause growth leapfrog out to neighboring jurisdictions. Applying the phases to less than all development sectors can lead to an imbalance of growth. The rates or phases can be used to ensure the adequacy of lumpy investments, such as water treatment plants, which serve the entire community and cannot be provided incrementally.

xiii) Mandatory low-income housing construction ordinance: These ordinances require those developing large residential projects (often over 50 units, sale or rental) to include a certain percentage of subsidized or low-cost housing (typically 10 to 15 percent of the total number of dwelling units). This requirement can be made economically feasible by tying it to the availability of federal subsidies or tax credits, or increasing allowable densities.

In addition to increasing the stock of lower income housing, these ordinances seek to avoid concentration and improve housing quality. In order to be effective the area needs to have growth pressures, a relatively high rate of return development, and there should be little opportunity to serve the same market by simply building in a jurisdiction without a low income ordinance. These ordinances may face substantial due process challenges.

xiv) Local environmental impact ordinances: Reports to local governments on environmental impacts generally mention alternatives, mitigation strategies, and irreversible changes.

By forcing developers to account for their environmental values, local governments gain the authority to encourage environmentally sound land use practices. To be effective, the local government must have the technical capacity to review the impact statements.

3. Land and Property Acquisition

a. Fee-simple acquisition of undeveloped land: Fee-simple acquisition of undeveloped land includes the purchase of the full "bundle of rights" contained in real property. Fee-simple acquisition of undeveloped land is important for two reasons. First, it can involve removal of hazardous sites from the private market, thereby reducing potential threat to the public. Second, fee-simple acquisition can act as a development management tool for guiding the location of development. Fee-simple acquisition can be prohibitively expensive, leading localities to alternative ways to finance and manage property, such as land banking and use of restrictive covenants.

b. Relocation of existing development: Relocation of existing development is the surest and safest way to protect it from hazardous threats. However, relocation can become more problematic if the buildings are large and heavy, making a move difficult. Relocation can also be very expensive, especially when there is a large amount of development in the hazard prone area.

c. Purchase of development rights/easements: The owner of an easement has one or more of the several rights in land, leaving the rest in the hands of the land owner. Easements either grant an affirmative right to use property, such as a right of access, or restrict the land owner's right to use the property in a particular way. Local governments can purchase an easement in development rights and thus preclude building on the property.

By owning the development rights, the government has a very high level of control while allowing the land to remain in private hands. However, the government does lose money twice: in the purchase and foregone tax revenue from the reduced property value. The government must also police the easement, since unenforced rights may eventually be forfeited.

d. Transfer of development rights: These programs treat development as commodity separate from land itself. The government awards development rights based on value or acreage of land, and establishes sending and receiving areas for these rights. The sending areas contain land the government, for various reasons, seeks to protect. In these zones landowners do not have enough rights to develop their land, but they can sell rights to developers in receiving areas. With these rights projects can take on higher densities than would otherwise be permissible. In addition to density, TDR programs can be used to affect the type of uses if the rights are for specific kinds of development, as opposed to one general purpose right.

Besides protecting sensitive areas, TDR programs are supposed to reduce the land value shifts of zoning by compensating those who can't fully develop their land. However, it is a complex system, which makes it difficult for planning staffs to implement and landowners to understand and accept. TDR programs alone cannot ensure quality development or that there will be a critical mass of resource operations (for example, that there will be enough farms to support the area's feed stores). Perhaps most importantly, the region must have enough development pressure to make the rights marketable.

e. Advance site acquisition (land banking): This technique involves the purchase of land by the government for eventual use or resale to the private sector in order to influence the character and/or timing of growth.

While on the surface land banking may seem simple, there are several potential problems, limitations and reasons for opposition: the public sector, rather than private landowners, receive the benefits of property value increase; value of land outside the land bank may be reduced because it eliminates the possibility of developer-contrived scarcities, and the government may sell land at below market prices; it requires high level of expertise on the part of planning staff; bridging the gap between revenues from sale of land and purchase of the land may require debt financing, which will create pressure to increase sale prices; the problems addressed by land banking are often regional, and thus beyond the power of most jurisdictions.

f. Purchase sellback/leaseback: The government can control the use of its land by selling or leasing it to the private sector with restrictions, covenants and/or negative easements.

In so doing the government maintains control without having to actually manage the property. Though less involved than management, the leasing or selling authority does need to ensure compliance with the terms of the agreement. Where the government sells the property, the restrictions lower the tax burden on the owner.

g. Purchase option (right of first refusal): A right of first refusal guarantees the government the first opportunity to purchase the property, while an option prevents the sale of the property to another party for specified period.

If the budget does not have room for an outright purchase, this can be an effective protection, but it can also be an unnecessary expense if the government will buy the property anyway. In addition, the property may become more expensive in between buying the option or first refusal right and the actual purchase. On the other hand, designation of future acquisition may reduce the property value, possibly making the government liable for damages if it does not go through with the purchase.

h. "Sword of Damocles" provision: A government agency with the power of eminent domain suspends condemnation of land covered by a comprehensive plan as long as the land use remains compatible with the plan. If the landowner proposes or commences a use in contravention of the plan, the land is taken into public ownership.

The federal government has used this approach in Idaho's Sawtooth National Recreation Area. These provisions allow land to remain in private ownership and are an effective, inexpensive protection tool in the short run. However, increasing land values may encourage property owners to develop incompatible uses and make the cost of condemnation prohibitive. If on the other hand, land values are suppressed by the provisions, governments may face political pressure to remove them.

4. Taxation, Fiscal, and Other Incentives

a. Differential assessment/taxation: This technique can take on several different forms: reducing the tax rate applied to the assessed value of resource production land such that payments only cover essential services; reducing the assessed value of resource production land such that payments only cover essential services; reducing the assessed value of land to a percentage of urban land; assess the value based on current income-producing capacity, as opposed to the market value (most states allow land in several specified uses, such as forests and open space, but some limit to farmland).

The differential assessment reduces the tax burden on land facing development pressure and recognizes that some tracts put less demand on services funded by property taxes. The flip side of this recognition is that the loss of tax revenue can be substantial. An unintended consequence of having preferential status is that it can be a haven for speculation as property value rises, and can force development further out as close-in property owners hold out and sustain tax benefits. This effect can be reduced with either a use change/conveyance penalty, or a deferred taxation system, where the difference between market and preferential taxes are paid when the property is converted to a higher use (laws vary, but the range is five to ten years of tax deferred taxes due). However, the amount of accumulated taxes may not be enough to offset profits, and there may be a leapfrog effect because land farther out will have lower market value and thus lower accumulated taxes. In addition, basing the tax rate on income production for a specific property will encourage development of best farmland because it will have the lowest accumulation of deferred taxes (which can be avoided by having a uniform rate). The few legal challenges have been based on uniform taxation provisions in state constitutions.

b. Land gains taxation, transfer or development taxes: Vermont is the only state to employ a tax on the profits gained from the sale of land. The amount is inversely proportional to the length of time land is held, and it can apply only to value of land, not improvements. There is an exception for the principal residence of seller. Transfer taxes are simply assessed against the seller of land devoted to certain designated uses. Development taxes are charged against developers obtaining permits to convert land in certain categories to more intense uses.

These taxes discourage conversion to higher density, slow the growth rate, and discourage speculation, but they also are not effective for long term protection and may limit needed economic development while owners hold out on selling their property. The land gains tax may be vulnerable to legal challenge under the uniformity clause in state constitutions or based on discrimination against non-residents because of the principal residence exception. On the other hand, the Vermont law sustained a Fourteenth amendment challenge of arbitrary discrimination against land owners of less than six years.

c. Special assessments districts: Special assessment districts include property owners who benefit from a specific public improvement. These owners are charged a fee, which can be based on an attribute(s) of the property that is proportional to the benefits received from the improvement, and is charged to both new and existing development. There are numerous possibilities, from temporary creations designed simply to raise revenue for a specific improvement to independent, special purpose governmental entities. A commonly used example is the transportation utility fee. While exactions, bonds, impact fees and other methods are used to pay for transportation improvements, the utility fee covers the maintenance/operation cost of the system(s).

Since this is not a tax, special assessment districts are free from constitutional requirements of uniformity, equality and double taxation. This technique shifts the financial burden from the general public to those directly benefiting. The revenues are more predictable than sources which depend on development cycles, which makes issuing bonds easier.

d. Impact fees/system development charges: These assessments are typically one time, up front charges (some jurisdictions allow extended payments) against new development to pay for off-site improvements. The fees can also be set up to have growth buy into existing services with excess capacity. Two specific examples of impact fees are: 1) Family Reservation Fees—where developers pay up front for their proportionate share of future improvements or expansions, and 2) Linkage Fees—where non-residential development finances needs linked to the new development, such as affordable housing.

Impact fees can fund wider variety of services than exactions or special districts, and can cover the full costs of improvement, unlike land dedication requirements. On the other hand, impact fees do not help with maintenance costs. They are typically used in place of negotiated exactions, which take longer and are less predictable or equitable. Finally, every impact fee must meet a three part legal test: 1) need for improvements is created by new development, 2) the amount charged the new development is proportionate, 3) all revenues must be spent in proximity to the new development and within a reasonable period of time.

e. Development impact tax/improvement tax: These are taxes on new construction, including alterations to existing structures, usually paid while applying for building permit.

Unlike a fee, this charge does not need to be based on the cost of improvements needed to serve the new development, and there are no restrictions on how the revenues can be spent.

f. Developer Exactions: These are private sector investments in public infrastructure needs created by new development. Exactions can take the form of on or off site improvements or land dedication, and are often a condition for approval.

There needs to be a rough proportionality between the exaction and the development’ s impact. For this reason land dedications are good, as they have a close relationship to the development, but dedications don’ t cover the cost of improvements.Negotiated exactions do allow financing of improvements and can be very specific, but they also create problems: improvements usually reflect the needs of individual developments and not the community as a whole; they are not predictable; particular geographical conditions or bargaining ability may make some exactions appear inequitable; small developments may not be subject to the same kind or degree of exactions as large ones, even though they can have the same or greater cumulative effect; exactions do not cover maintenance costs.

5. Capital Facilities Policy: This technique creates a timetable and budget of when, where, and what level of municipal services a government will supply.

The timetable controls growth because it is rarely feasible for a developer to provide services, and capital programming is less expensive and less likely to face legal challenges than many other growth management techniques.

a. Focused public investment plan (FPIP): Basically a Capital Improvements Plan for a specific area, known as a Public Investment Area (PIA). A Focused Public Investment Plan (FPIP) coordinates and concentrates investments such as water, sewer, streets, schools and parks. While funding mechanisms and expected contributions from developers may vary, the objective is to supply fully served land for development.

FPIPs limit growth which is dispersed and has inadequate public services. PIAs allow governments to choose which parts of the jurisdiction are suited for growth, which can include areas free of environmentally sensitive features and infill/redevelopment sites. Carefully chosen PIAs will also minimize the overall cost of providing services. FPIPs make it easier to create a system of development charges which is equitable and understandable to the developer.

b. Service areas: The taxing authority of a government can designate areas which will receive services and those that will not, and tax the former at a higher rate.

This technique will be more effective if used in conjunction with a regulatory program which limits development in areas with lower, more attractive tax rates, and a capital program will make the designation more equitable and less open to legal challenge. (The uniformity of taxation provision in most state constitutions can be the basis for legal challenge.)

c. Marginal cost pricing: Under this system new development is responsible for the incremental cost of the service needs it creates (for example, paying per foot for water and sewer) as opposed to average cost pricing (charging the same regardless of real costs). The latter form of pricing creates an incentive for low density growth away from existing services, since it is effectively subsidized higher density, close-in development.

The complexity of marginal cost pricing leads to the creation of price districts instead of pricing each development, which can lead to a problem at the district borders; people will understandably ask why they have to pay more than their next-door neighbor.

d. Concurrency/Adequate public facilities requirement: This is a required level of municipal services that must exist when the proposed development is completed or within a certain period afterward.

The requirement can have the effect of encouraging development in areas already well served by public facilities, and/or shifting development to jurisdictions with lower service requirements. Demanding service requirements also may discourage certain types of development, especially high density.

6. Land Use Policy: The above development management tools should be incorporated into well defined policies (such as expressed through a comprehensive or land use plan) that address the location, density and use of land, paying special attention to high risk areas. Development should be located away from high hazard areas. Density should reflect the impacts of development on the environment, as well as the ability of local government to protect the community, and need to evacuate the area. Use of land should be also be reflective of the impacts on the environment and reduction of hazards.

7. Moratoria: A moratorium is a short-term suspension of right to develop, usually done by not issuing permits. Moratoria can play an important role following a disaster, to set priorities for response and potential mitigation efforts.

8. Reconstruction Triage: Reconstruction triage is the sorting of priorities for reconstruction. The use of a triage for decisions on reconstruction should be outlined in a post-disaster reconstruction plan, created prior to the disaster.

B. Subdivision Regulations: The division of a lot, tract of parcel into two or more lots, tracts, parcels, or other divisions of land for sale or development.

C. Information Dissemination

1. Real Estate Disclosure Requirements: Real estate disclosure requirements would require notification that the property to be purchased is located in a hazard prone are notified of this. Currently, federally regulated lending institutions must advise applicants for a mortgage or other loan that it is to be secured on a building which is in a floodplain as shown on the Flood Insurance Rate Map. Since this requirement has to be met only five days before closing, often the applicant is already committed to purchasing the property when he or she first learns of the flood hazard. State laws and local practices by local real estate boards can overcome this deficiency and advising newcomers about the hazard earlier. They may also require disclosure of past disaster events, regardless of whether the property is in a mapped high risk zone. Terms and maps of used for disclosure of hazard risk should be meaningful to homebuyers.

2. Community Awareness Programs: Community awareness programs may be used in conjunction with and/or in place of real estate disclosure requirements to directly educate the potential homebuyer and the community of hazard risks. Information can be presented in a number of ways, including information pamphlets, brochures, literature and workshops. Topic may include identification of hazards, things to consider in purchasing a home or business, ways to limit exposure and reduce future property damages.

3. Hazard Disclosure

a. Mapping Hazards: The application of vulnerability and/or risk analysis, inventories, and other studies to maps is an important step in reducing disaster potential. Locating hazards can be accomplished through cooperation with a number of federal and state agencies. Use of a geographic information system to overlay high risk areas over property maps can serve as indicators of sites for mitigation.

b. Notification: Notification of the locations of hazards and the risks needs to be given to public officials, public employees and agencies, the general public, and the private sector. Notification can be given through workshops, information pamphlets, brochures, literature, etc. It is important that information on the location of hazards is shared between agencies to ensure better decision-making.

4. Disaster Warning: The first step in responding to a potential disaster is to know that one is coming. This may require monitoring of local conditions. Disaster warnings can be administered in a number of ways, including via sirens, radio, television, cable TV, mobile public address systems, telephone trees, and even door-to-door contact. Multiple or redundant warning systems are most effective, as the message will received even if one part of the warning system is not heard.

5. Workshops: Workshops can play a valuable role in preparation for a disaster. Workshops can be arranged for public employees and/or state agencies, for general public, and for public officials. These workshops should include education regarding the potential hazards, possible mitigation steps that can be taken, and how to respond after a disaster occurs.

6. Education and training: Education and training for awareness of hazards, mitigation steps, and disaster response should not only be targeted to public employees, agencies, and public officials, but should also include the general public and the private sector.

III. Private Sector

A. Lending: The application of a real estate disclosure requirement or other information to lending sources regarding the risk of development in hazard prone areas would reduce to cost of lending both to the lending institutions and consumers of their services. It is important that lending institutions understand the risk of supporting development in high risk areas.

B. Insurance: The insurance industry plays an important part in the private sector guiding of development. The National Flood Insurance Program is a good example of how the insurance industry can also play a role in promoting development that reduces hazard risk.

C. Building Industry: The building industry should be educated to the structural and building codes designed to reduce damage from hazardous events. The building industry should also be educated on the location of high risk areas and ways to mitigate hazardous threats.

Glossary

Barrier islands. Elongate bodies of sand thrown up by parallel to a coast line by the waves.

Barrier reef. A long ridge of coral near and parallel to the coast line, separated from it by a lagoon.

Barrier rollover. Response by barrier islands to rising sea level through erosion on their oceanic sides and deposition of the material by overwash on their back sides.

Blowout. Depressions formed by wind in sandy areas where the vegetation has been removed.

Coral reefs. A ridgelike or moundlike structure composed of corals and other aquatic organisms, occurring in shallow water along some subtropical and tropical shorelines.

Debris flows. Very rapid downslope movement of rock and regolith.

Deflation. Wind erosion of sediments.

Deflation basin. A depression formed as wind blows sand from a surface unprotected by vegetation.

Delta. A depositional plain formed by a river as it enters a standing body of water, such as a lake or the ocean.

Diversion culverts. Channels that are excavated along the top of a slope to intercept water flow and protect the lower slope from erosion.

Dormant volcano. A volcano that has not erupted within historic time but is capable of erupting in the future.

Dunes. A rounded hill or ridge of sand heaped up by the action of the wind.

Ebb surge. The return of flood surge waters, stream flow and precipitation back into the ocean as a hurricane moves inland.

Ebb surge channels. Roads, driveways, and channels perpendicular to the coast that channel hurricane flood flow across the shore back into the ocean.

Effluent streams. Streams that receive most of their discharge from the ground water table.

Extinct volcano. A volcano that is not expected to erupt again.

Eye. The center of a hurricane, an area of relative calm and very low pressure.

Eyewall. The area just outside of the eye of a hurricane, which is the location of the greatest turbulence and highest winds.

Fetch. The distance over which wind blows.

Fissure eruptions. The ejection of lava from a crack rather than a vent.

Flood. An overflowing of water beyond the channel' s capacity.

Flood barrier. A moveable wall or series of gates that can close off a waterway to protect it from hurricane storm surge.

Flood frequency recurrence curve. A graph that expresses in years the likelihood of development of a flood of a given height.

Flood hazard map. This map shows areas that would be flooded by stream discharges of a given magnitude (for example, a "50-year flood").

Flood impoundment dam. A containment structure that holds rainwater so it can be released slowly after a flood.

Floodplain. The flat plain on either side of a stream that is flooded periodically.

Flood tide. Landward flow of estuarine water with the rise of the incoming tide.

Floodwalls. Reinforced concrete structures parallel to the river banks which prevent floodwaters from inundating the settled areas behind them.

Foreshocks. A small seismic event preceding a greater one and originating at or near the same place, caused by minor breaks in stained rocks, especially along tributary faults.

Fringing reef. A coral reef growing outward from the shore with no open water between it and the shore.

Greenhouse effect. The process by which increases in natural and anthropogenic carbon dioxide and other atmospheric gases have trapped more and more of Earth' s heat, thus increasing atmospheric temperatures.

Groins. Walls of rock, concrete, or wood built perpendicular to the land into the surf zone to trap sand and build up beaches.

Hazard map. A map showing areas that are affected by a particular hazard such as lava flows or stream flooding.

Hermatypic. Reef-building corals in which the coral animals live in a symbiotic association with algae.

Hurricane. A massive low pressure system of tropical origin with rotary winds that exceed 119 kilometers per hour (74 miles per hour) blowing counterclockwise around a relatively calm central area called the eye.

Intermittent streams. Streams that flow only part of the year, when the groundwater table rises to fill their channels.

Jetties. Long rock or concrete structures built into the surf zone on either side of a tidal inlet to prevent the inlet from closing through deposition of sand carried along the coast by longshore drift.

Lateral erosion. The sideward erosion by a stream as it migrates over its floodplain with time.

Lava. Molten rock that has extruded on to Earth' s surface.

Lava dome. A volcano built up of viscous lava that does not flow far from the vent before it solidifies.

Lava flow. Magma that reaches the surface non-explosively and spreads out.

Levee. A ridge of sediment deposited alongside a stream as floodwaters rising out of the channel lose energy and deposit their coarser load.

Longshore drift. Movement of sediment along a shoreline by successive waves.

Magma. Molten rock beneath Earth' s surface.

Mercalli scale. A scale to measure the intensity of an earthquake as perceived by humans.

Mudflows. Mud containing significant water (up to 30 percent) and a large proportion of fine-grained material.

Overwash. Sediment washed by storm waves through low areas between dunes and onto the back side of a barrier island or inland across the mainland.

Pancaking. The process in which poured concrete floors separate from their corner fastenings and fall, floor by floor, onto each other as a result of seismic shaking.

Perennial streams. Streams that flow year round because of a high water table and humid climate.

Plate tectonics. A theory that explains the movement and deformation of parts of the outer Earth. It involves the movement of rigid lithospheric slabs, called plates, over a less rigid layer (the asthenosphere).

Quicksand. A sand/water mixture that is fluid because water flows upward through the deposit and exerts pressure on sand grains, keeping them from touching each other.

Saffir-Simpson scale. Used to describe the relative power of a hurricane on a rating scale (category) of 1 to 5. The scale utilizes wind velocity and storm surge heights to assign a category to a given storm.

Seawall. A wall built parallel to a coast to protect it from wave erosion.

Seismograph. A detecting instrument that times and records incoming waves during an earthquake.

Seismology. A branch of geology that studies earthquakes and the passage of earthquake waves through Earth.

Sheet flow. The excess water that flows over the land surface in a layer when the rate of rainfall exceeds the infiltration rate.

Slide. A mass movement process in which rock or sediment moves downslope along a planar surface.

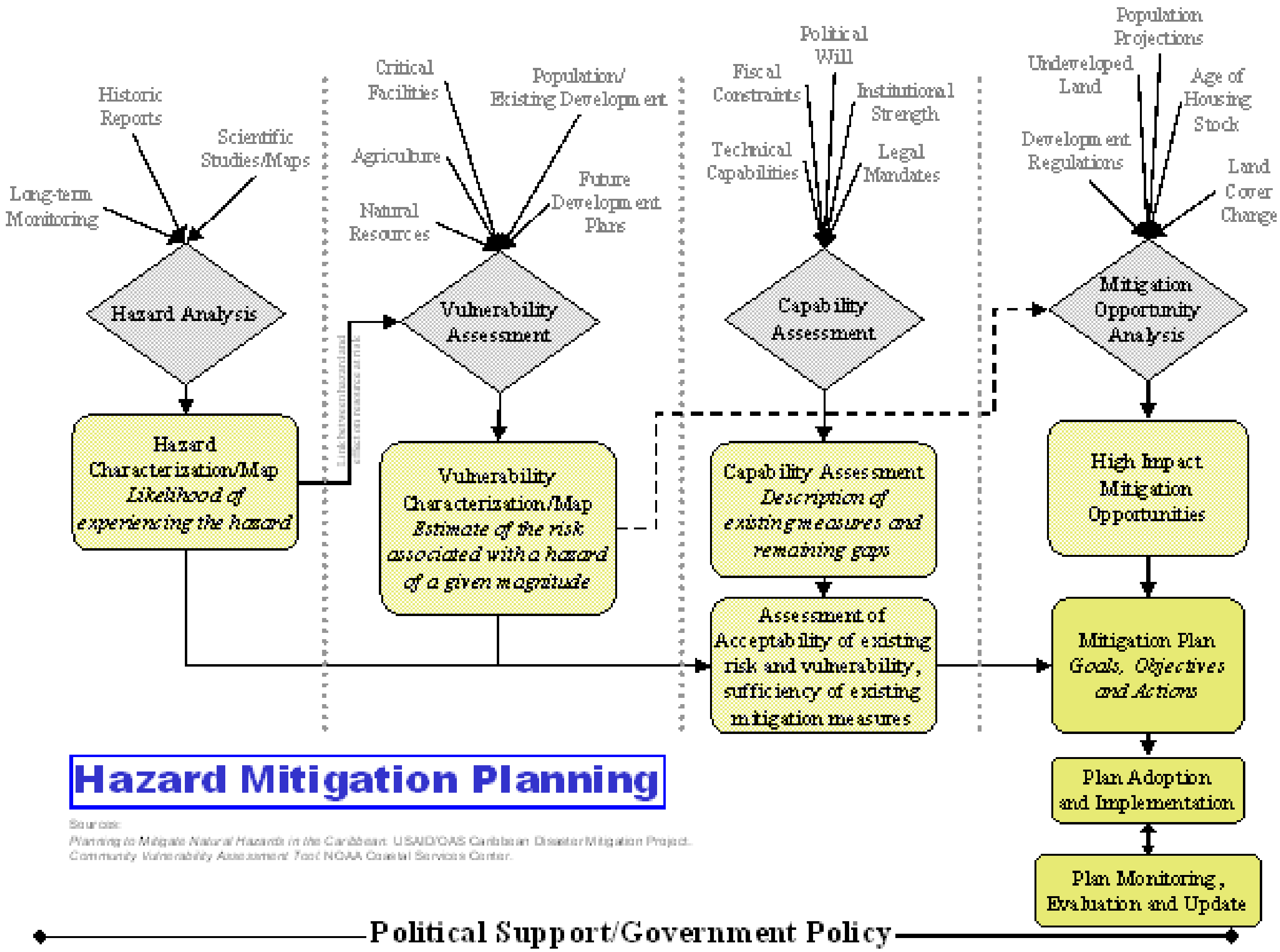
Storm surge. An elevation of the ocean surface resulting from the compound effects of water being pushed shoreward by wind across decreasing depths on the continental shelf, low pressure at the sea surface, tides raising the water level, and winds raising the ocean surface.

Subsidence. Sinking of the ground surface due to the removal of large quantities of water or petroleum from the pores of underlying sediments or rocks.

Tsunami. Seismic sea waves generated by a major disturbance of the sea floor and overlying water.

Washover fans. Lobe-shaped deposits of sand eroded from the ocean side of a shoreline and deposited in the bays behind the barrier island.

Hazard Mitigation Planning Flowchart



Sources

1. *Planning to Mitigate the Impacts of Natural Hazards in the Caribbean* — a mitigation planning manual produced by CDMP, October 1997: *Mitigation Planning Manual*.
2. U.S. National Oceanographic and Atmospheric Administration's [Coastal Services Center](#).